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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 5 : B60R 16/02, H04L 5/00, 5/14, 29/02 — A1

(11) International Publication Number: WO 94/26558

(43) International Publication Date: 24 November 1994 (24.11.94)

(21) International Application Number: PCT/AU94/00237

(22) International Filing Date: 6 May 1994 (06.05.94)

(30) Priority Data:

PL 8702	7 May 1993 (07.05.93)	AU
PM 1475	27 September 1993 (27.09.93)	AU
PM 2337	10 November 1993 (10.11.93)	AU
PM 2338	10 November 1993 (10.11.93)	AU
PM 2354	11 November 1993 (11.11.93)	AU
PM 3059	20 December 1993 (20.12.93)	AU

(81) Designated States: AT, AU, BB, BG, BR, BY, CA, CH, CN, CZ, DE, DK, ES, FI, GB, GE, HU, JP, KG, KP, KR, KZ, LK, LU, LV, MG, MN, MW, NL, NO, NZ, PL, PT, RO, RU, SD, SE, SI, SK, TJ, TT, UA, US, UZ, VN, European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG).

Published
With international search report.

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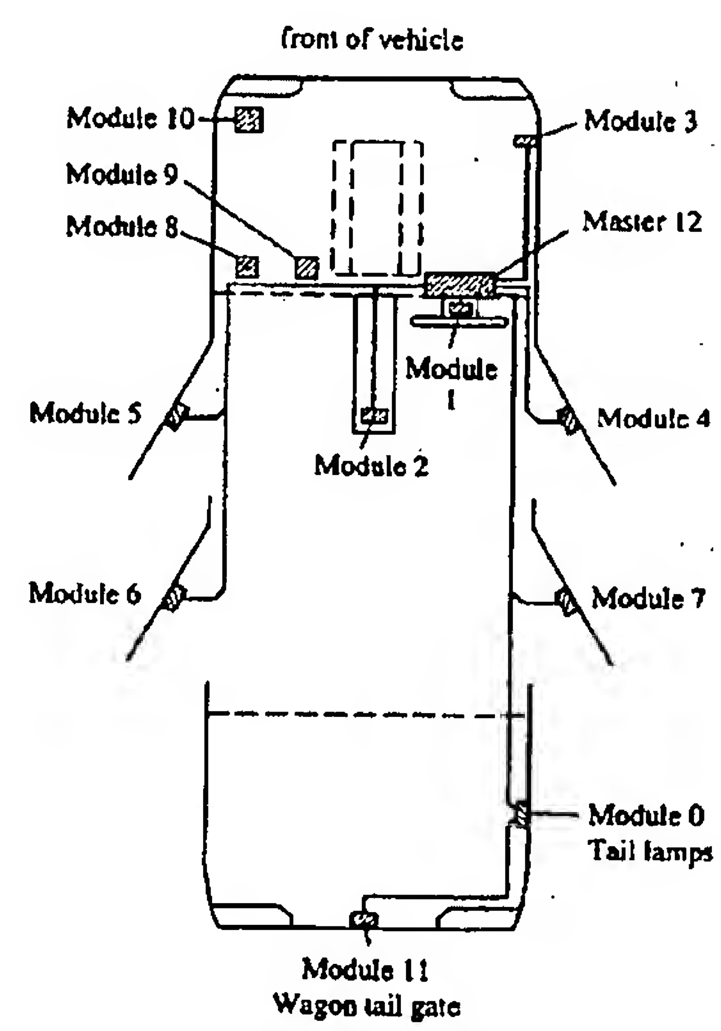
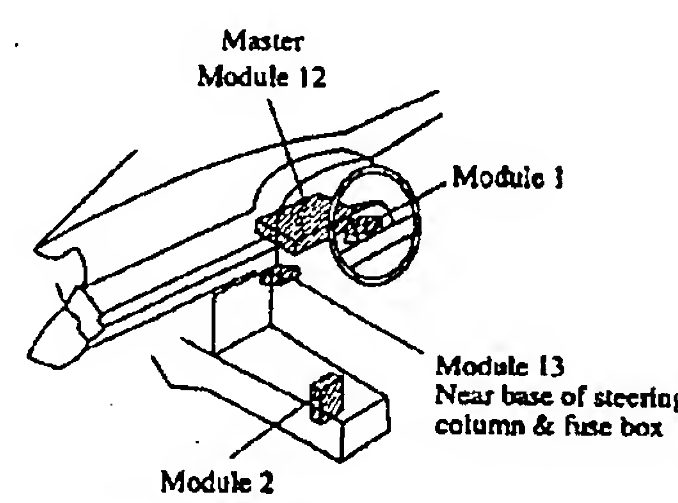
(54) Title: VEHICLE COMMUNICATION/CONTROL SYSTEM

(57) Abstract

A system for a vehicle having a master module and at least one slave module. A vehicle control system wherein a module is juxtaposed the steering wheel/column or centre of the vehicle. A control system for a vehicle wherein a module is coupled directly to an instrument cluster. A system for a vehicle wherein the master module has at least two buses. A communication system adapated for use in a vehicle wherein the master module polls a slave module. In a vehicle, a system wherein coupling between modules is provided by four wires used for transmit, receive, supply and return. A communication method of transmitting data one way asynchronously and the other way synchronously. A communication method of initiating the transmitting of a reply before the whole message has been received.





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VEHICLE COMMUNICATION/CONTROL SYSTEM

FIELD OF INVENTION

The present application relates to communication systems, protocol and topology particularly, but not exclusively, adapted for use in vehicles.The present invention relates to a control system, and particularly to a control system for a vehicle or other apparatus or device. The vehicle may be adapted for transport or conveyance by land, air and/or water. Further, the present invention relates to a control module topology for a passenger carrying vehicle. The invention also relates to vehicle multiplex control, wiring configurations, communication systems, topology and/or protocols therefore.

BACKGROUND ART

In respect of topology prior art, several communication systems have been heretofore proposed, many of which are directed at modifying or replacing existing wiring harnesses in vehicles. Invariably, the prior art has utilised individual wires connected from a master or central control 'brain' to each remote device (such as a brake light, windscreen wiper etc.), or the prior art has utilised a high speed single bus link, from which a number of remote devices are connected (a one bus, multi-drop LAN). The prior art is considered to be relatively unreliable as, in the case of a break down or fault in the LAN, the whole or a substantial portion of the master/remote communications system may be disabled. A vehicle is thus disabled and may be considered undrivable.

In a majority of cases these are often of a standard configuration and are not adapted to enable ease of problem diagnosis nor quick and efficient design changes in the configuration of vehicle wiring harnesses. The existing vehicle harness art usually consists of a range of harness based on total cost of vehicles;

a) low end market,
b) medium market,
c) high end market.

Vehicle wiring looms currently used are also considered to be relatively bulky & comprise relatively large numbers of wires. This provides significant vehicle design constraints due to requirement to fit the loom and its associated

connectors within the vehicle body structure. Such vehicle looms also couple to a centralised body control module (BCM) and this tends to increase the length and number of wires required in any one vehicle.

Other vehicle control systems utilise multiplexing, such as that disclosed in US4594571. This system utilises a master module and 5 slave modules and is considered to be relatively expensive in its application to a base or medium range passenger carrying vehicle. For example, the system disclosed in US4594571 shows 2 slave modules in the engine bay, and 2 at the rear of the vehicle. This is considered to add unnecessary cost and thus detracts from adoption of this technology by the market place.

Another problem is considered to exist with stalks used on steering columns which have relatively bulky mechanical switches. These switches are invariably hard wired to a BCM, relays, actuators or lamps by way of a relatively large number of wires which run within or around the steering column. The physical size of the column is considered to limit the number of wires provided down and within the column. This has tended to inhibit the type and number of functions provided in a stalk which is at a drivers command.

Due to complexity and cost, if features are to be added, (eg., a security system, electric mirrors or electric seats etc.) these are only added to the high end market cars and usually represent special production runs to the standard harnesses used on base model vehicles in the low end market.

Other problems exist, in that some harnesses are damaged during installation by their:

a) size,

b) complexity,

c) location.

More sophisticated harness systems have been developed utilising a centralised micro processor which is hard wired to all the devices in a car. This results in a requirement for large amounts of wiring from the extremities of the car back to the location of the micro processor. This increases the flexibility of application but increases harness size and complexity and therefore the overall cost.

In respect of signalling system prior art, as depicted in Figure 4, vehicle looms electrically couple vehicle devices and components to a central control BCM (Body Control Module) denoted M.

In base model vehicles, forward of the vehicle, a loom may be used which comprising up to 60 wires between the fuse block and the BCM. In the dash area of the vehicle, a vehicle loom invariably comprises a relatively large number of wires and connectors. Further, vehicle loom which serves the rear area of the vehicle can comprise up to 20 wires. These must be fitted interior of the vehicle body panels.

In the case of medium or highly featured more luxury vehicles, there is usually even more wiring provided. For example, with the advent of ABS systems in vehicles, further demands are placed on the space occupied by vehicle looms, giving rise to a conflict between the open area required within the vehicle panels and dash to accommodate the wiring loom(s), and the requirement for fitting devices, components and providing panel strength in the vehicle.

Much of the problems result from the way in which electrical activation of devices is provided. For example, Figure 2 and 14, and the operation of a simple light switch. If we look at a single light switch operating a single light bulb, we can see that by turning the switch on and off, we can control the bulb's operation. In order to control a second light bulb independently, we require another dedicated switch, and an active and/or return wire for each bulb and thus a duplication of Figure 14. Given the number of electrical devices in a vehicle, lights, instruments, etc., it can be seen that large wire looms have become a necessity in prior art configurations. Even the fusing operations provided by the fuse block, treats each bulb, instrument and device as a separate item.

Due to the approach of vehicle designers to the having a centralised location of fusing (fuse box) and vehicle control via a BCM, relatively large looms (area) result.

Further advances in prior art utilise multiplexing communication systems, such as that disclosed in PCT/DE90/00784. Such systems are 3 channel or 3

signal systems. One channel (wire) is provided for both transmitted and received data between the BCM and a remote device (such as a light bulb), one channel (wire) for 12V supply, and a third channel (usually not by wire) being ground via chassis return.

Such multiplex systems, in order to be operatable in vehicles, operate at a band rate above 10 kb/sec. This is because, such systems use a single channel for both transmission and reception of data between the BCM and the device to be operated, and thus data speeds are required to be relatively high in order to enable the system to overcome lost time due to bus contention or to simply react quickly when required.

In respect of vehicle communication protocol prior art, multiplex vehicle control systems currently utilize a single channel (wire) for both transmitted and received signals. Such systems are usually microprocessor based and require a slave or satellite module to generate an interrupt function before a particular operation can be undertaken. For example, the operation of braking would entail a signal to be generated upon movement of the brake pedal, the signal serving as an interrupt to the microprocessor, who thereafter would take what ever steps are necessary, such as activation of brakes and/or brake lights.

The type of communication used in such systems is usually either all synchronous or all asynchronous. Coupled with the provision of only one transmission/reception channel between the master and each slave module, there has been a need to speed up the rate of data flow. This increased data flow rate has proved necessary as a result of the relatively limited time available for a multiple system to receive, issue and act on commands, for example in the act of braking of the vehicle.

The result of increasing the data flow rate in prior art arrangements has been the adoption of higher and more costly technology, and hence relatively more expensive components. Thus, on the whole, vehicle manufacturers have remained with more traditional wiring looms or harnesses as these have proven to date to be more reliable and/or cost effective than multiplex systems previously developed for vehicle application.

OBJECTS OF INVENTION

An object of the present invention is to alleviate at least one disadvantage of the prior art.

A further object is the provision of an apparatus, protocol and/or method of operation which serves to enhance the applicability of multiplex systems to vehicle operation.

SUMMARY OF INVENTION

Throughout this document, the term "module" is intended to be construed to include so called " electronic centres", hubs, junction blocks, connection blocks, fuse blocks, electronic controllers, programmable controllers, logic controllers and/or logic components.

The disclosure herein also details a number of aspects relating to control devices, especially for vehicles. Some aspects are described separately.

The present invention, in one aspect, seeks to provide a more reliable and robust vehicle wiring configuration, topography and/or inter-relationship.

The present invention is predicated on the discovery that a multi-bus, multi-drop communication system can be adapted to vehicles and / or generally to communication systems for control of attached devices.

The present invention provides a communication system adapted for a vehicle, the system comprising:

a master module which serves to provide instruction to at least one remote device, and

a multi-bus network between the at least one remote device and the master module.

In the system disclosed, if one of the busses is faulted or disconnected, the rest of the system (and thus, remaining vehicle features) can still operate. This solves a long felt need in the vehicle industry as reliability is substantially increased. Maintenance and fault diagnosis is also enhanced since a part of the whole system can be diagnostically isolated and preferably attended to in case of a fault.

The busses of the present invention can be accessed by the master module in a number of ways, including preferential polling or sequential polling

basis. Appropriate software can be configured to enable bus access as required.

The present invention also seeks to provide a more reliable and robust vehicle wiring configuration while reducing size, complexity and cost over existing methods.

In its broadest form, the present invention has application where wiring harnesses are currently used, for example in the automotive, aerospace, maritime, building, manufacturing and toy industries.

It is considered that, unlike prior art disclosures, the present invention, in another form, is predicated on the provision of a topology, in which modules whether master and / or slave are specifically positioned, the topology being applicable to a vehicle in which at least one system module is positioned so as to reduce or minimise wiring costs.

Thus, the present invention provides a vehicle control system wherein there is provided a master control module, and 1, 2 or 3 slave modules.

In another form of the invention, there is provided a slave module proximate the front of the vehicle, a slave module proximate the steering column and/or a slave module proximate the centre of the vehicle.

In a specific form of the present invention, there is provided a master control module and 2 slave modules, one proximate the front of the vehicle, for example in the engine bay, and one module proximate the steering column, for example in or near the steering wheel. This specific form of the invention is considered most suitable for, but not exclusively, for base model vehicles.

A further invention provided as a result of the reduction or minimisation of wiring cost in a vehicle is the placement of a module proximate the steering column.

In another form, the present invention provides a slave proximate the steering wheel of a vehicle and/or coupled to the steering column. This enables more features and/or features of greater complexity to be accommodated in or around the steering wheel of a vehicle.

The present invention also provides a base or medium model range vehicle including the features noted above.

At the central point is a Master module which polls Slave modules for change in input status and then relays this information via data wires to the correct slave module which then operates the desired output.

This allows in the present invention for a Master module to control a bus network of preferably four wires to which can be attached a number of Slave modules, as required by the user. The apparatus of the present invention consists of 2, 3 or 4 wires, one for power, one for transmission of data, one for reception of data, and one for ground. However, the invention may be also realised in a wireless arrangement (eg. RF) where the modules are individually powered. The invention may also be realised in a combination thereof, or may comprise TX and RX wires, the power for the modules being sourced elsewhere.

Each slave unit preferably has a logic circuit that controls the local functional ability of the module.

On system start-up each individual slave is polled by the master to determine states of inputs/outputs and service level of operation. This may be preset.

The allocation of slaves functionality may be set, in accordance with an input to the Master processor preferably on start-up, such as an algorithm, or some other method/apparatus.

Furthermore, it has been found that by utilising multiplexed signals between master and slave modules. The master memory may be adjusted and reconfigured to allocate a function which controls the security system such that the existing control apparatus can be utilised without further cost penalty.

In another aspect, the present invention provides a form and/or method of communication between, for example, a master module and a slave module which has asynchronous communication in one direction and synchronous communication in the reverse direction.

Another invention provides the initiation of reply communication between master and slave modules before a transmission has been completed.

In yet another aspect, the master polls the slaves. This is considered useful as a back-up or fail safe system where one of the channels of the system

noted above fails or is corrupted. In such failed or corrupted situation, a more conventional communication protocol and method can be adopted by the system of the present invention (hardware and / or software) to facilitate continuing system operation and preferably using the remaining channel(s) of the system. Selection of a failsafe mode may be by user manually or automatic of the system.

The present invention is predicated on the principle of having a different based signal outgoing from that incoming, preferably where two communication channels are used. That is an asynchronous transmission would invoke a synchronous response or vice versa. This enables a relatively smaller period of time to be occupied by any one transmission and reception of a command. This in turn enables for a given number of commands to be sent and responded to, a relatively shorter period of time overall or the adoption of slower and less expensive technology components, non-descript wiring and connectors and less or no wire shielding where the baud rate of data is lowered. Such a less expensive adoption would have relatively significant cost ramifications in the manufacturing of, for example, vehicles.

The present invention also provides a control apparatus comprising:

at least one slave processor, each slave processor being adapted to control at least one remote device; and

a master processor adapted to provide address and control of information to each slave such that preferably, the master and slave processors communicate by a multiplexed receive and transmit signal.

The present invention also provides a method of communication in which data is transmitted in one direction on a channel asynchronously and in the reverse direction synchronous.

There are also significant advantages in a lower baud rate as there is less chance of data corruption. Given this, error correction bits in the bytes transferred between master and slave modules may, in one form, be removed. This would even further facilitate increased speed and/or the lowering of the rate of data transfer.

In yet another aspect, the present invention provides a four channel vehicle control and/or communication system together with a relatively decentralised connection layout.

The invention is predicated on the principle of enabling relatively low baud rates (at least below 10 kb/s) by the provision of separate transmission, reception, supply and return channels, together with the provision of vehicle device coupling via a plurality of non-centralised hubs. A device(s) may be coupled to a relatively short distance to the hub or module conventionally by way of supply and return channels, however connection between module(s) and master module is provided by way of the 4 channel system.

Thus, the present invention provides in a vehicle, a system for coupling electrical devices, said system comprising;

a plurality of modules provided in a spaced relation to a master module, and

at least two channels or wires coupling between the master and each module. Further supply and return channels may be additionally provided.

In this way, the looms which conventionally occupy a relatively large area within the vehicle can be replaced by a 2, 3, or 4 channel system. This serves to provide significant wiring cost and space savings in vehicles.

Having separate transmission and reception channels also serves to enhance reliability. For example, if the transmission or reception line is broken, then the master module may be adapted to switch to the remaining line to provide some form of communication and/or control of the vehicle.

Preferred embodiments of the inventions outlined above will now be described with reference to the accompanying drawings, wherein:

Figure 1 shows a form of the "TREE" system of the present invention.

Figures 2, 3, and 4, show conventional microprocessor communication methods.

Figures 5 and 5a show a preferred TX frame construction;

Figures 6 and 6a show a preferred response frame RX;

Figure 7 shows one topology of a module in accordance with the present invention;

Figure 8 shows one topology in accordance with the present invention;

Figure 9 shows another topology preferred layout of modules within a vehicle;

Figures 10 and 10a show one form of a protocol for use in the present invention;

Figure 11 illustrates another topology in accordance with the present invention. This topology is considered suitable for a base model vehicle;

Figures 12A, 12B, and 12C show embodiments of the preferred placement of the slave associated with the steering wheel and/or steering column;

Figure 13 shows the preferred wiring configuration; and

Figure 14 shows prior art.

Figure 15 illustrates input/output interface between master and slave modules.

Figure 16 illustrates voltage thresholds for signal waveforms.

Although the preferred embodiments relate to a harness layout for a vehicle, the present invention should not be so limited and has application anywhere a harness or loom is currently used or required. Such uses may also be in machinery or devices which include looms or harnesses. Furthermore, although the drawings depict various embodiments showing a right hand drive vehicle, the inventions and aspects disclosed herein also have application to left hand drive or rear or mid engine mounted vehicles. For such vehicles, a mirror image of what is illustrated may be incorporated, but other topology configurations are also herein contemplated bearing in mind the layout of master and slave units in the vehicle and the requirement to increase system reliability and / or reduce system wiring cost by way of the inventions and aspects disclosed herein.

A BRIEF DESCRIPTION USING AN AUTOMOTIVE APPLICATION

This system as used in vehicles, requires the following conceptual changes to be considered as far as normal physical operation is concerned.

In the following description, one form of master module is referred to as VCM, and one form of slave module is referred to as RTM.

In a standard vehicle, it is conventional design practice to arrange devices in clusters for ease of manufacture (eg. rear lamp assembly). These clusters normally have a common wire to chassis and each device in the cluster is activated by its individual switch which then supplies positive 12 volts via an individual wire. The device then draws current via this wire and returns it to the common chassis point. There are also a few devices in a vehicle that operate with the reverse polarity switching method eg. they have 12V connected to one terminal and the switch connects to a chassis earth.

The TREE (twin remote electronic environment) system in one form can be configured such that the following changes are made in the identified clusters. The common chassis earth is in one form can be removed from the chassis and connected back to the module. The other wires are then connected to a module's outputs that can then be switched to operate a device. This then alleviates the need for a metallic chassis in a vehicle, allowing composite materials to be used where it was once uneconomic to do so due to practical limitations on harness size.

Figure 1 shows a preferred form of the present invention, implemented in a vehicle. Slave modules (S) can be provided at various points in the vehicle, depending on the features provided in the vehicle. For example, a front door slave, may be used to control remote devices such as a door lock, a window and/or external mirror.. Communication between the slave and master modules is provided by a multi-bus system, and as shown in an exemplary manner all but one bus has only one slave thereon. Bus "A" has a number of slaves coupled thereto and this is termed 'multi-drop'.

The single master is not confined by a set method of an TX / RX line when talking to numerous slaves.

As shown, it can have either a single slave on any particular RX and/or TX bus or it can have more than one slave on a bus.

The system of the present invention contemplates one bus per slave, one bus per 2 or more slaves or a mixture thereof, depending on the requirements of the vehicle manufacturer. A preferred embodiment is to have 4 channels (Rx / Tx) with 1 to 4 slaves off each channel.

With reference to Figure 2, a single master talks to a single slave, similar to a modem link. In Figure 3, a single master talks to several slaves all connected to the same RX/TX line. This is similar to a high speed LAN network. In Figure 4, a single master talks to several slaves all connected to different RX/TX lines. This is similar to a optical telephone network. Figures 2, 3, and 4 illustrate various forms of prior art.

Figures 5, 5a, 6 and 6a, 10 and 10a illustrate one form of communication protocol useful in the present invention. Any form of communication is considered to be useful in the present invention, and thus the present invention should not be limited to the particular form now disclosed. The form disclosed nonetheless does have significant advantages over conventional forms of communication, not the least of which is a relatively faster communication speed given that over a given period of time substantially more data can be transferred between master and slave.

As illustrated, the protocol used for the master / slave intercommunications is asynchronous RX at the slave and synchronous RX at the master. These asynchronous / synchronous transmissions may be vice versa. All communications are controlled by the master, in the form disclosed. Slaves may nonetheless in other forms perform controlling functions. The slaves in one form respond to the master after receiving and recognising their own address field. The slaves nonetheless may communicate to the master without first receiving a master address.

The slaves, in one form, sync to the master on the start bit. The slave monitors the RX line at preferably 8 to 16 times the baud rate. When the start bit has been detected (4 to 8 consecutive high clock polls) the slaves internal clock is started which corresponds to approximately the middle of the start bit. From this point the slave will clock a further 26 bits at the baud rate frequency regardless of whether the slave is the target or not.

The slave sends its data after it has recognised its address. This is preferably, using the protocol shown in Figures 5, 5a, 6 and 6a, after the master sends bit 7 or 16 of the TX data word. The master clocks in this data bit a further bit plus a relatively small delay (to allow for transmission loop delays).

The protocol described has application in a Master/Slave topology multiplex system as disclosed herein, but should not be limited to such application only.

The protocol is not to be limited to the size or function only as described which is suited in one form to base or medium range vehicles. In higher optioned or more expensive vehicles, more data or addressing may be required, however the principles and generality of the inventions noted above should still apply.

Figures 5, 5a, 6 and 6a show an exemplary transmitted and received bytes between master and slave modules. The master polls the slaves. This reduces or removes the requirement for an interrupt function, and thus the need for a microprocessor based system which is considered to be too expensive.

The relative shortness of time for transmission and reception of any one set of data also facilitates the ability for the master to have the time to poll all connected slaves rather than the prior art arrangement where the master is reactionary to an interrupt from a slave in a microprocessor based system.

In Figures 5, 5a, 6 and 6a, the master begins to transmit the data. As the present applicant's multiplex system does not have a microprocessor topology, the transmission from the master module can, if preferred, go to all channels simultaneously and therefore allow for parallel processing of the data received from the slaves on each individual channel.

With reference to figures 10 and 10a, Bit 6 or 3 respectively is the first data bit in this example. After it has been received by the slave on the transmission channel, the slave can commence a response transmission to the master via a receive channel. At the same time, the next data bit, bit 7 or 4 respectively, can be received and synchronously responded to as bit 2 or 1 respectively from the slave on the receive channel to the master module.

In this way, with the use of asynchronous transmission and synchronous reply, a data length of 25 bits (15 transmit from master, 10 transmit as reply from slave), or 41 bits (28 transmitted from master, 23 transmitted as a reply from slave) respectively, can be accommodated in the time usually taken by 16 or 28 bits.

Figures 10 and 10a also serve to illustrate the above example and provides some detail of the contents of the preferred transmitted and reply bytes. These may be varied dependent upon the system application.

The present protocol has been found to work well in a vehicle application at approximately 10,000 b/sec. or less, and even at 4800 b/sec. Most manufacturers have data rates at approximately 8192 b/sec. At these relatively low data rates, the provision of wiring other than non-descript wiring and connectors nor shielding of wiring from EMI been necessary due to the reduced baud rates workable with the present inventive aspect. Thus significant savings can be attained overall in a vehicle, or other device.

In another embodiment and again with reference to Figures 10 and 10a, all communications are controlled by the master and the slaves only respond to the master after receiving and recognising their own address field.

Data integrity is checked with a simple parity bit and stop bit combination. An even parity scheme is observed and the party bit is set or reset accordingly. Only the data bits are included in the parity check. If a parity or stop bit error is encountered the data is ignored and in one form the watch-dog output is not pulsed for this frame. In the event of the TX or RX I/O'x being held high (low on the comms lines) the parity will register high when it should read low therefore no data will be accepted and the watch-dog will not be pulsed. If the TX or RX I/O's are held low (high on the comms lines) then no stop bit will be detected and the same result will occur (the slave would not detect a start bit either).

Overall slave message synchronisation is assured by having a inter-slave message gap equal to one slave message time slot. This ensures that at the beginning of the master frame (slave 1) all start bit clocks are synchronised to the correct bit (start bit). If noise should confuse a slave as to which bit is a start bit, this is resolved during this gap (after slave 4) and should correct any problems on the next scheduled time slot for that slave. Worst case single error fault condition will therefore be one master frame.

It is also important, as another aspect of the invention, that due to the asynchronous transmission and synchronous reply, there is not a need for a

clock line (channel) to be provided between master and slave(s). This has a further cost advantage in wire savings in a vehicle, or device.

The system is flexible enough to allow a high degree of design freedom because it uses Asynchronous NRZ signalling. This is used in conjunction with the two polling modes (sequential, preferential) with signalling being either continuous or discontinuous.

The RTM's compare their known address with that transmitted by the VCM and upon a match being detected the data is stripped from the bus and acted upon. The RTM's return the data representing the state of their inputs back to the VCM.

The VCM is programmed to analyse the data and decide on a course of action, with the decision parameters being set by the requirements of a particular manufacturer.

The optional micro processor is only required on more complex vehicle optioning which warrants the cost of inclusion.

The VCM & RTM's use a modified square wave in Asynchronous NRZ mode to communicate.

In one from an RTM can be polled in the following manner. (Continuous sequential polling a priority)

Add 1, Add 2, ..., Add X ....., Add N

Where, Add X consists of start bit synchronization bits, RTM address, RTM data, CRC bits, parity bit.

In another form an RTM can be called in the direct access method.

Add 1, Add 1, etc.

Priority Polling.

Add 1, Add 2 Add 1, Add 3, Add 1, Add 4.

Upon recept on a correct address each RTM transmits its input/data back to the VCM for processing. The VCM recognises receipt of this data as confirmation of an RTM's functionality and bus viability.

RTM data is protected by use of a parity bit and CRC bits. In the event of an extremely hostile EMI environment the VCM resends the data by repolling the RTM. Software enhancements are built into each RTM IC to counter a long

period in hostile EMI environment, with recovery to VCM control being achievable once the EMI levels are acceptable.

Software controls in the VCM and RTM's allow for backup modes of operation for

- Rx failure
- Tx failure
- bus failure
- RTM failure
- EMI outside design tolerance

The driver/receiver circuitry is protected against ground and power rail shorts.

In yet another preferred form of invention, a relatively small delay of one or more frames is provided between transmissions between master and slave(s). This gap is useful in allowing transients, if present, to settle and/or act as a time in which the system as a whole to synchronise, read for another command transmission/reply.

DESCRIPTION OF A MODULE

With regard to Figure 7, each module is comprised of the following parts in the prototype development:

a logic device such as a gate array for handling the software routines;

a voltage converter to convert vehicle battery supply to an acceptable micro controller supply; and

a selection of output blocks that provide the switching means for a variety of devices.

Each module is equipped with software that can be selected via pin voltage settings. The module is capable of taking an input from an external switching device, that alters the state of a bit addressable pin on the IC when activated.

In each system one module is selected to be the Master module. This is for data security and system control. There will be sufficient Slave modules attached to the system dependent on the needs of the user as defined by availability of pins for identifying the slave.

The Master module has software designed to poll each of the modules (both Master and Slave) that are attached to the data wires. This allows it to receive any inputs activated on a Slave module and to decide an action based on these inputs. It also transmits to a Slave module any action it has decided upon. It can also contain a lookup table to interpret the logic settings that define the system. This method is the most memory efficient, but there are other methods that are available dependent on the needs of the user (such as interrupts).

The transfer of data is achieved via the two data wires at the preferred nominal rate of 10,000 bits/second (less chance of corruption). This data is contained in one frame which contains destination information along with data to be acted upon. This frame also indicates a request for an answer to the Master.

To simplify the explanation of a typical action to reaction, an example of the operation of a brake pedal causing a brake light in the right hand rear of a car to illuminate, will be used. This model assumes that the system is active and that the Master module has the brake pedal input attached directly to itself. See Figure 9.

Taking it from the stage where the master is sequentially polling the Slaves as well as its own inputs (in this case the brake light is on Slave 0):

1. The Master detects an activated input on its own module inputs (the brake pedal is operated).
2. It stores this information and then decides on a course action as determined by software.
3. It decided that the course of action is an output on Slave O.
4. When the polling step for Slave 0 is due it inserts the appropriate action into the TX frame and transmits it.
5. Slave 0 then interrogates the data received and determines that it has to activate an output to turn the brake light on.
6. A feedback sensor block on the module, monitors the effect of the gate array to turn the brake light on. The software is written to ensure that a requested action has actually occurred.

7. If a problem, such as a blown globe occurs, then this data is sent back to the Master module for interrogation as part of the RX data frame.
8. The Master module then determines a suitable course of action, which could be the illumination of a warning light on the dashboard to inform the driver of a problem.
9. The Master module then continues to poll each slave in sequence as before.
10. The warning light would remain active until the fault was fixed.

The TREE system has the following features;

1. Operates at a nominal rate of 10,000 bits per sec. - asynchronously on the TX line.
2. Has user defined polling sequences - synchronously on the RX line.
3. Can control the output of power consuming devices.
4. Each module slave ID is determined by the designer.
5. The system can be defined by the user within the limitations of the software.
6. A very large system can be built up from just the two basic module configurations (Master/Slave).

SOFTWARE

The software for all the Slave modules is the same for reducing the cost of manufacture. It is the selection of the slave ID pins that will determine the function of an individual module and its own unique ID. The Master module would have the further option of determining the structure and function of the system. However there can only be one Master module in any one system.

<u>Slave Module</u>

Each slave module carries out the following functions.

1. Sense a change of state on its inputs.
2. Activate an output when instructed to by the Master module.
3. Perform first in fault analysis on device failures.
4. Be able to communicate with the master module.
5. To identify its position within the system as determined by its pin settings.

Master Module

The Master module has all the Slave module abilities plus the following;

1. It is used as a central processing control centre for any defined system.
2. Can have its memory set by the user to define the system via pin settings.
3. The polling sequence can be user defined.
4. Performs second level fault analysis to slave module level.

The gate array / logic controller is designed such that the reception and transmission of data is from three pins using a trinary state data line method.

Data is transferred along a common two wire bus using a frame format as described in Figure 10.

The software in the master module sets the address and action information then transmits it to the TX frame. The slave module responds with the result of its input data which also confirms it is still active (a watchdog function). Software in the slave module ensures that only the slave that is addressed will respond. All slave modules are polled in sequence and vetted by software in the Master module for a positive response.

In a contemplated ASIC version each module will have the facility to self test its inputs and outputs. This will provide ease of maintenance and repair of the present invention when necessary.

ADVANTAGES

These would be as applies to the automotive application.

1. The size of the modules when made as an integrated unit.
2. Simplicity of cabling eg. only needs a maximum of 4 wires for communication even for quite large systems, or may require no wires in a wireless system.
3. Able to carry out all the functions of an existing car wiring system.
4. Can provide security system functions using the same bus system as that used to replace a wiring system.
5. The TREE system can be adapted for installation by robots.
6. It offers higher reliability and is more robust in a working environment than other systems currently available.

7. Any functional system upgrades in the future can be done by replacing the Master module and adding only small harnesses to connect from an appropriate slave and the new output device.
8. It offers a simple user interface for maintenance and repair of electrical faults.
9. Any diagnosis to be made by an auto electrician can be simplified and thus made more cost effective.
10. Can be incorporated into the concept of circuit board dashboards.
11. As the present invention may be realised in only a relatively small number of components, such as 4 or less wires and any associated modules, savings may be realised by OEM and After-Market installers. The savings may include wiring, cable clips and accessories, inventory and storage for these components, installation personnel. The invention may also lend itself to more compact design of products as space saving may be realised where previously relatively large harnesses had to be accommodated, and other similar savings.
12. The flexibility of the module design allows for smaller more compact harness design as any additions of features can then be done by modifying small harnesses.

OPTIONS

The following options are of a broad range if it is considered that the TREE system can be as simple as a one module system to as complex as is required by a user.

1. It can replace existing multiple wire control systems.
2. Allows for a revision of the current automotive electrical design practices.
3. Can be integrated to form a total vehicle security system.
4. Provision of simple low cost fault analysis at various levels.
5. Can be combined with state licensing requirements to limit access to a vehicle to certain times and to limit the speed for certain drivers.
6. Can be used for fleet management when combined with a memory storage unit.
7. Can be used in all types of vehicles or heavy duty stationary plant.

8. Has parallel applications in;
   a) Aerospace industry
   b) Maritime industry
   c) Building industry
   d) Manufacturing industry
   e) Toy industry

Figure 11 shows one form of layout of modules for a vehicle. With this type of layout, one harness can be used for a number of vehicles. The remote devices (eg. brake lights and switches, etc) can be fitted as normal during manufacture for each type fo vehicle and simply connected to one design of harness.

Some benefits of the present invention may be summarised with regard to the TREE system. It is a cost saving modular alternative to the existing wiring harness system used in automobiles. With the following additional benefits;

1. Standard modules and connections can be used in any vehicle in the world.
2. Incorporates a security system at very little extra expense.
3. Can be retro-fitted to all existing cars.
4. Can be used with existing electronic technology already used in cars.
5. Is compatible with the concept of a circuit board dashboard layout in cars.
6. Involves no additional plant at installation phase unless robots are used to offset labour costs.
7. Less prone to mechanical and chemical damage both at installation and in later life.
8. Can be used to replace any cable operated system currently used in cars (eg. bonnet release) if the appropriate action device is also installed.

The VCM has control of the system while the bus is fully functional and the system design allows for any output to an actuator to be completed within a few milliseconds. Because polling is used, system latency will always be determinant, and proportional to the number of I/O on a particular channel.

The system uses a master (VCM)/slave (RTM) protocol to overcome bus and to also allow for deterministic I/O delays. Each VCM and RTM has

appropriate driver/receiver circuitry to access the bus with only 1 IC being required at each VCM and RTM location in its minimal base model vehicle configuration.

1,2 or 3 MODULE TOPOLOGY

In one form the system was specifically designed for the automotive industry to accommodate a base model vehicle and any subsequent optioning levels independent of any specific automotive manufacturer.

It provides for simple, yet reliable and robust communications between a Vehicle Control Module (VCM) or master and a Remote Termination Module (RTM) or slave. This system allows for two polling modes (e.g. sequential and preferential) with the module topology configured for the lowest cost implementation.

The complete set for a typical base model vehicle system consists of 2 x RTM and 1 x VCM with an optional micro processor within the VCM dependent upon a manufacturers requirements in terms of options and designer flexibility.

Referring to Figure 11, there is disclosed a vehicle control topology which has been found to provide relatively reduced or minimum wiring topology. This should not be viewed as the only topology according to the present invention, as a number of slave modules can be provided as and where required in the vehicle or apparatus, for example, Figure 9.

The coupling between the master module and each slave module is preferably by way of a channel system as disclosed herein, there being at least two channels, one for power and one for communication. Four channels are preferred, supply, ground, transmit, and receive.

As to the relative location of the master or slave modules 1, 2 and 3, this will vary from one vehicle model to another, depending on the features provided in the vehicle. Nevertheless, it is envisaged that the topology shown in Figure 11 is suitable for a majority of vehicles.

The specific form of the invention considered most suitable for base model vehicles is also illustrated by the representation of Figure 11, however slave module 2 may deleted for cost reasons.

Module M is a master module. The master module serves to poll each slave module. Nonetheless, the master module may also have direct coupling of vehicle devices to it, such as the instrument cluster, warning lamps, engine management controller, power train control and dash switches. In one embodiment, the master may be incorporated in, directly connected to or at least closely associated with the instrument cluster. This list is not exhaustive, and merely reflects some of the type of vehicle features usually proximate the location of the master module. Thus the master module may be seen as an economical point of connection. Thus, positioning of the master module can be made bearing in mind:

1. Integration of master module and existing instrument cluster -
    - cost benefit over leaving master as a separate module
    - shared componentry, such as circuit board
    - eliminate wiring between master and instrument cluster
    - reduced electrical connectors leads to higher reliability
    - general deproliferation of components
    - more compact cockpit module design.
2. "Piggy-back" master module to the instrument cluster -
    - eliminate wires between master and instrument cluster by using fixed connectors and mechanical mating method.
3. Separate positioning of master module may also be appropriate where wiring is preferred between the master and one or more slaves.
4. In engineering or dashboard, dependent on minimal wiring and wiring cost considerations.

Slave module 1 is preferably located on, within or about the steering wheel and/or its associated steering column. Figures 12A, 12B, and 12C provide some exemplary placements of slave 1. Figure 12A shows one preferred form, where module 1 is provided within the steering wheel. Figure 12B shows another preferred form, where module 1 is provided on the wheel. There is thus room in the wheel to provide an air bag. Figure 12C shows module 1 proximate the steering column.

Where module 1 is placed in or proximate the steering wheel, only a 4 channel communication link to the master is necessary via the column. Thus, where the prior art has a relatively larger number of wires sometimes as many as 60, passing along the column, the present invention uses only 2, 3 or 4, but preferably 4 wires.

In such a situation, the wiring and switches provided in or on the steering wheel can be altered considerably. For example, the mechanical switches of the prior art, in the case of a horn switches, requires relatively heavy active and return wires to cope with the many amperes flowing in the wires when the horn is activated. In the present invention, however, a relatively small, membrane, solid state or other switch can be provided to send a digital ON / OFF signal by wire to module 1, located proximate wheel. The horn activation signal is then passed along the control system, via master module to a module to which the horn is activated. That module may send a digital or low level signal to a relay, which in turn will close a supply circuit to the horn, for horn operation.

It should be readily understood that the fact that there is reduced wiring between the steering stalk switches and module 1, compared to prior art, that cost reductions in wiring can be achieved.

Furthermore, the present system dispenses in the majority with mechanical switches. Thus, considerable space savings can be had. As a result, more and/or smaller switches can be accommodated in one given area, or switches can be provided in more convenient locations, such as on top of an air bag in the centre of the steering wheel or on a stalk.

The present slave modules are located substantially to effect reduced or minimal wiring, and in a preferred form.

Module 1 - in steering column - coupled to steering stalks, ignition barrel, driver switches near wheel.

Module 2 - proximate the centre of the vehicle and primarily in order to connect to devices toward the rear of the vehicle. Various features can be coupled to module 2, including where provided power windows, rear door functions, rear of the vehicle functions such as lamps, fuel pump, boot lock. In one form, Module 2 is to be coupled to any features in the vehicle rear of the

front seats. In another form, the seats may also be coupled where they are electrically adjustable.

It has been found that in base or medium range model vehicles, the provision of wires to the features of in or about the rear of the vehicle is less costly than the provision of a number of modules in or around the rear of the vehicle. In more expensive and more optioned vehicles, more modules, in addition to module 2, may be used.

Figure 9 shows such a more optioned vehicle, where M is the master module 12.

Module 1 is located proximate the steering wheel.

Module 2 is located proximate the centre of the vehicle.

Module 3 is located in the engine bay.

Modules 4, 5, 6 and 7 are located in the doors.

Module 0 is located for tail lamps.

Module 11, for station wagons, is located for rear gate or boot.

Module 8 ECC-electronic climate control.

Module 9 ECM-engine control and preferably engine train for engine and gearbox.

Module 10 forward lights and fittings.

Module 13 near base of steering column and fuse box.

Module 3 - in or around engine bay, generally forward of the fire wall or dashboard.

It is envisaged that the modules and particularly module 3, can have relays accommodated external to the module in an early embodiment. At a later time and with the use of an "Integrated Relay" technology, the subject of copending application filed by the present Applicants, and/or the use of solid state relays, the relays may be accommodated internal and/or external of the module as required by a customer.

In the present system, if extra features are to be added such as ABS, power windows, CD player, etc., it is necessary to hard wire the device to the nearest module (slave or master). The operating software of the overall system can then be amended to accommodate the new feature(s). In this way, the

present topology serves to provide the ability for a vehicle manufacturer to add features to a vehicle at a reduced hardwiring cost due to the reduced use of hardwiring.

A preferred form of the invention encompasses a base or medium range vehicle having a master and 3 slave modules and/or the provision of a module in or around the steering wheel.

The position of the modules as disclosed above provides further advantages, and in particular the ability to more readily locate and isolate fusing problems. In current vehicle design, fusing is centralised which exposes a relatively large amount of wiring to potential problems. Also, a problem in one area of the vehicle, may in turn, cause fusing or operational problems which would be seen in other areas of the vehicle.

With the present topology, the fusing and/or problem areas are more localised due to the more localised positioning of the modules. It is anticipated that fusing can be provided on one or more modules and therefore enable more ready identification and location of a problem in the vehicle.

Also, due to the use of the Applicants 4 channel communication and control system between modules (master and slaves), an electrical fusing problem is not readily transparent through a module. The module provides supply/return power switching to vehicle devices, whereas inter-module communication and/or control is via transmission/reception lines in a digital and/or multiplexing format.

In one particular form, the master module may fuse the dashboard area, module 1 the steering area, module 2 the rear area and/or module 3 the forward area, as illustrated in Figure 11.

Figure 8 illustrates another embodiment in which there is provided the master/3 slave module system detailed above, and in addition, a slave module in each forward door.

A preferred embodiment will now be described

Figure 3 discloses one embodiment of the present invention, in that the wiring coupling between module(s) and master is disclosed. Compared with Figure 14, it can be seen that the same number of vehicle devices are

controllable in Figure 13, but with 4 wires (channels) rather than 16 wires as shown in Figure 14. Modules A and B are expandable, without increasing the number of wires interconnecting the modules.

Noting that the 4 channel connection is shown between modules, this may be provided as 4 wires, (transmit, receive, supply, return) or 3 wires where the return or supply is via the chassis.

The decentralised and 4 channel features are significant in the reduction in wiring achieved by way of having vehicle devices coupled directly to the module(s), as indicated with reference to Figure 11 by 2 for rear devices and 3 for forward devices in the vehicle. Wires 2, 3 do not need to be coupled directly to the master module M. The master module M serves to provide principal control of vehicle functions, whether directly or indirectly via modules.

Some devices may be coupled directly to the master where such devices are relatively closely located, for example vehicle instrumentation, dash board controls and power train management, as previously described.

The system utilizes dual wires (Rx/Tx) in non-shielded random lay for automotive use.

The transmit wire (Tx) carries the serial output from the VCM to the receive input of the RTM's on each channel.

The receive wire (Rx) carries the serial outputs from the RTM's to the receive input of the VCM on each channel.

The transmit and receive signals are therefore separated and occur simultaneously greatly increasing the throughput of the communication bus.

Normal attenuation considerations with respect to bus length apply (eg. cable impedance, baud rate and clock speed variations) making maximum transmission line length a variable controlled by the designer of a system.

The system typically has one VCM master (Vehicle Control Module) and a number of RTM slave (Remote Termination Modules) spread across a number of Bus channels.

With reference to Figure 15,

Rx Block provides comparator and hysteresis actives to combat battery voltage fluctuations and provide noise margin respectively.

Tx Block blocks have tri state capability utilising a push-pull arrangement, to allow for the case when more than one RTM is required on a particular Rx channel. Output waveforms are wave shaped to limit rise and fall times with regards to emissions.

In respect of signalling, it is preferred that LOGIC high levels are at approximately battery voltage for automotive applications, comparator circuits are used in the receive circuits of the VCM and RTM's to set logic high threshold at half the battery voltage plus a hysteresis margin. This technique provides relatively reliable communications at battery voltages fluctuating as low as 4 volts. Figure 16 illustrates an example of voltage ranges and tolerance in an automotive application.

There is a plug in diagnostic module which shows the logic status of all I/O from the bus. Thus it is straightforward to isolate a fault to a particular input or output circuit.

The VCM and RTM IC's have a power reduction mode to reduce ignition off (sleep mode) power consumption. This is used when the system is placed into the vehicles security protection mode. The VCM is used as the reference for switching between normal mode and sleep mode upon detection of ignition on/off and/or security on/off.

Regarding Clock Tolerance, each RTM has its own clock reference but for determination of integrity of data on the bus each RTM synchronizes to the start bit of each address frame using 16 times over sampling method.

Regarding Data Rate, the data rate is determined by the VCM software and need not be fixed. However, testing and research has indicated a nominal rate of 10 Kbps is economical for automotive use without cost penalty in components or design.

THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1. A control system for a vehicle comprising a master module and three slave modules.

2. A system as claimed in claim 1, where one slave module is provided in the forward portion of the vehicle.

3. A system as claimed in claim 1, where one slave module is provided for coupling to the rear portion of the vehicle.

4. A vehicle control system comprising a module provided juxtaposed the steering wheel or column.

5. A vehicle control system comprising a module provided juxtaposed the centre of the vehicle.

6. A vehicle control system comprising a master control module and at least one slave module coupled thereto.

7. A control system for a vehicle or device in which there is provided a master module coupled directly to an instrument cluster.

8. A control system, device, protocol and / or method as herein described and / or illustrated.

9. A communication system for a vehicle, including
a master module having at least two buses coupled thereto, each bus including at least one slave coupled thereto.

10. A system as claimed in claim 9, wherein at least two buses each have at least two slaves coupled thereto.

11. A vehicle including the system as claimed in any one of claims 1 to 10.

12. A method of communication in which data is transmitted in one direction on a channel asynchronously and in the reverse direction synchronous.

13. A method as claimed in claim 12, wherein the synchronous data is reply data.

14. A method of communication in which a reply transmission is initiated prior to completion of a received transmission.

15. A method as claimed in claim 12, 13 or 14, where the reply or response transmission overlaps, in time, the received transmission.

16. A communication system utilising the method of any one of claims 12 to 15.

17. A communication system, adapted for use in a vehicle and having a master module and at least one slave module, wherein the master polls the slaves.

18. A vehicle having the systems of claim 16 or 17.

19. In a vehicle, a system for coupling electrical devices, said system comprising;

a plurality of modules provided in a spaced relation to a master module, and

at least two channels coupling between the master and each module.

20. A system as claimed in claim 19, wherein the two channels include

a transmission channel, and

a reception channel.

21. A system as claimed in claim 19, including a third, supply channel and a fourth, return channel.

22. A system as claimed in claim 19, wherein a first module is provided for coupling rear of vehicle devices, and a second module is provided for coupling front of vehicle devices.

23. A system as claimed in claim 22, wherein the first and/or second modules are located to substantially reduce the amount of wiring in the front and/or rear of the vehicle respectively.

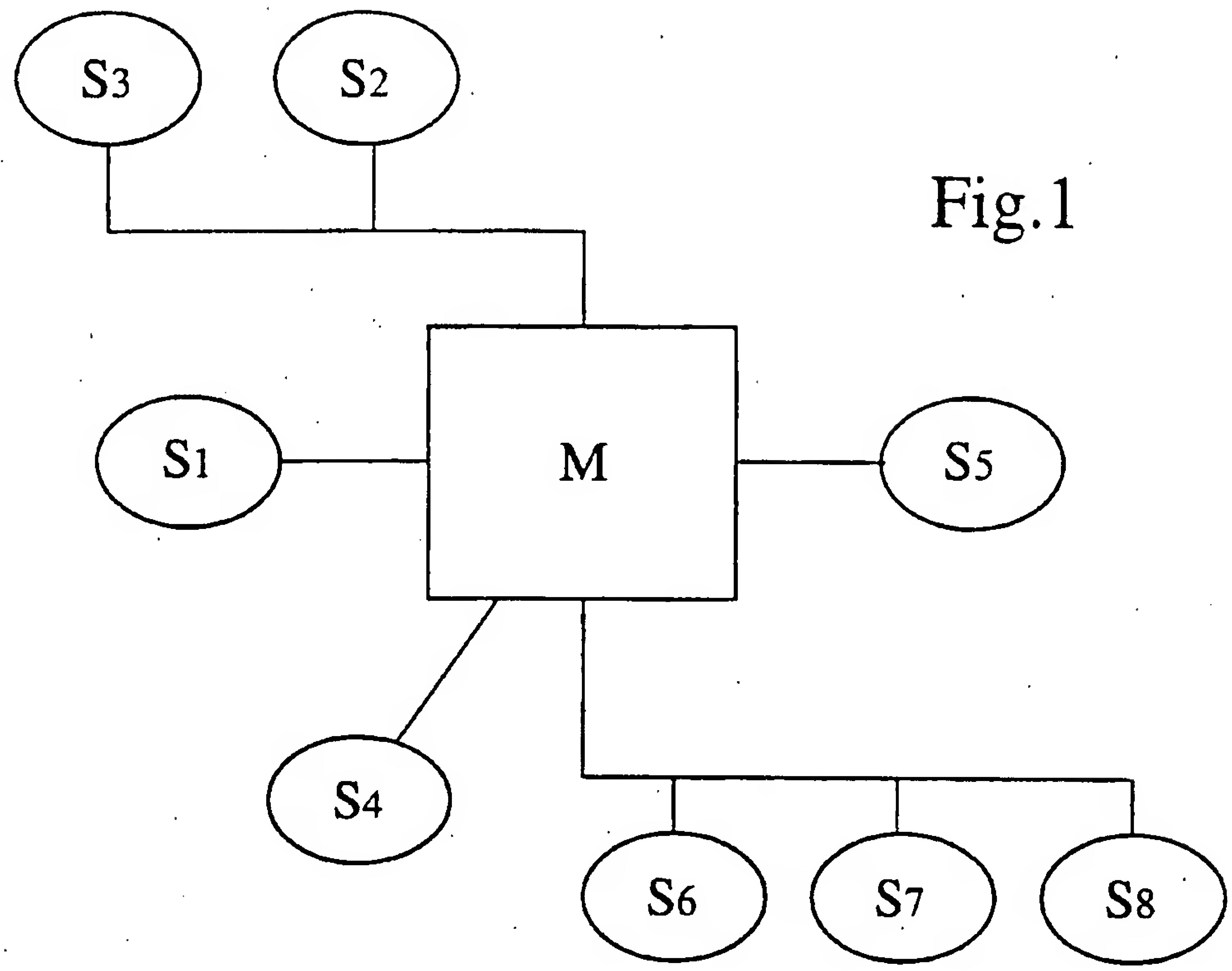


Fig.1

Fig.2 prior art

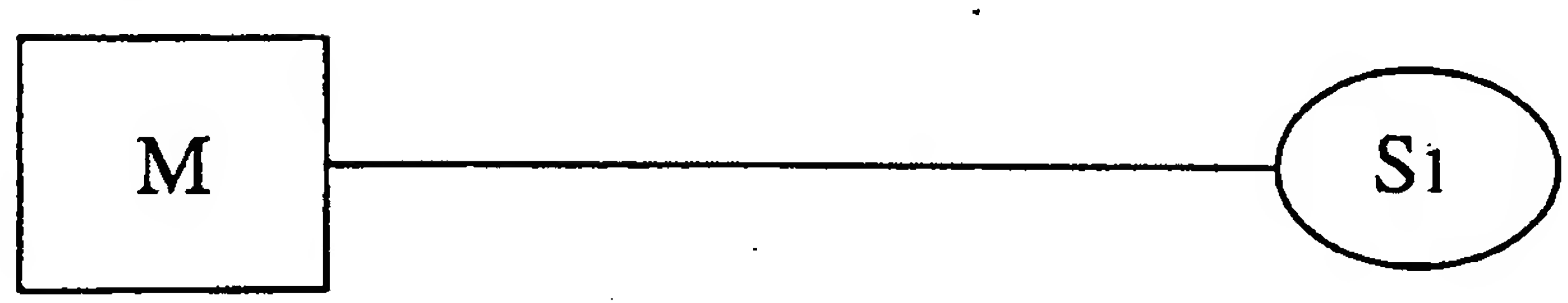


Fig.3 prior art

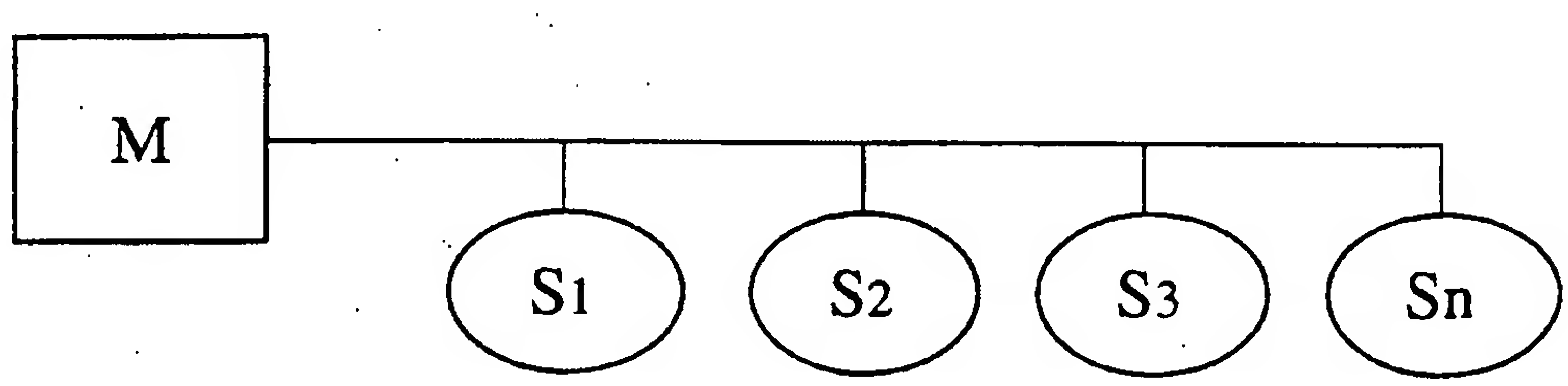


Fig.4 prior art

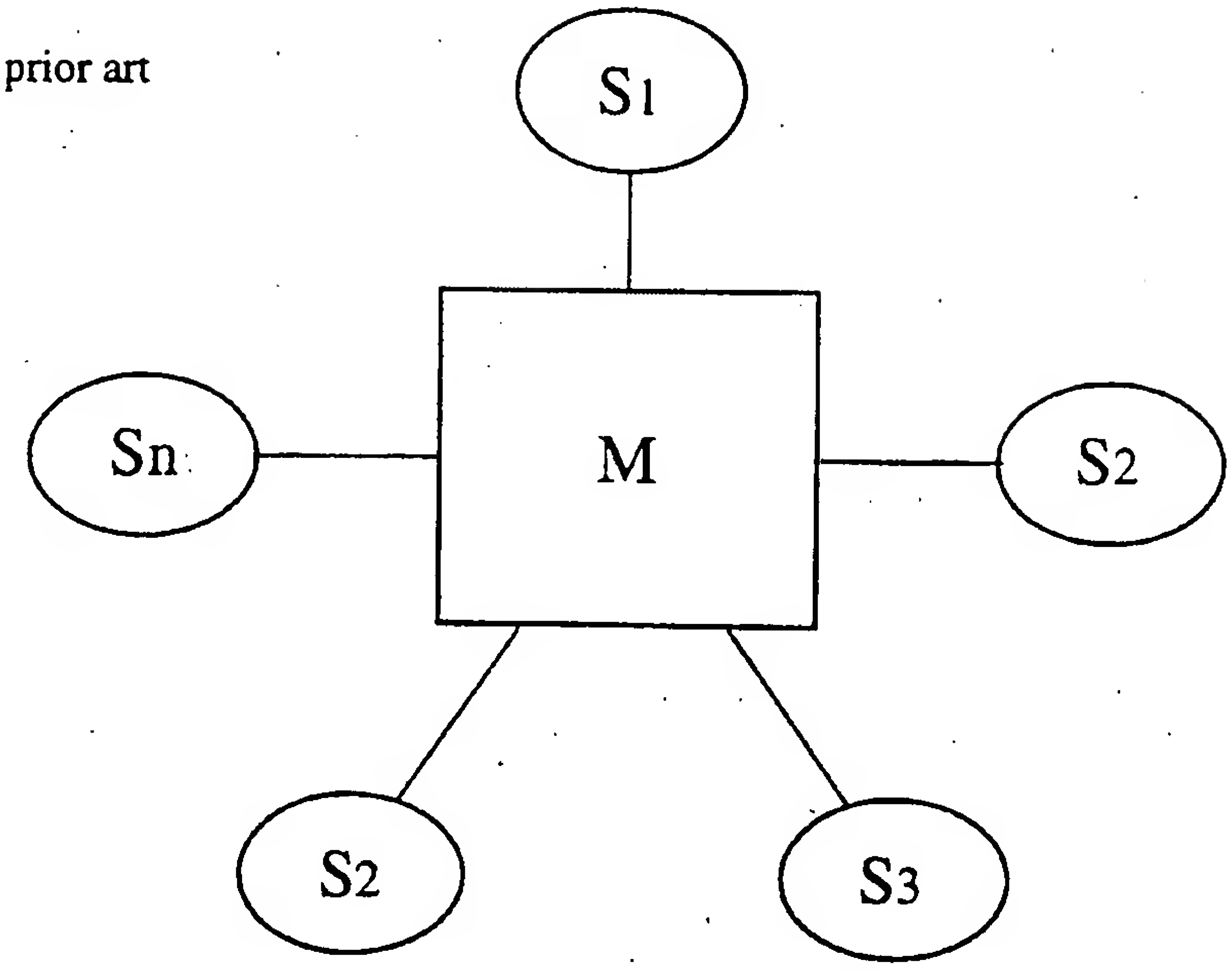


Fig.5 (Tx)

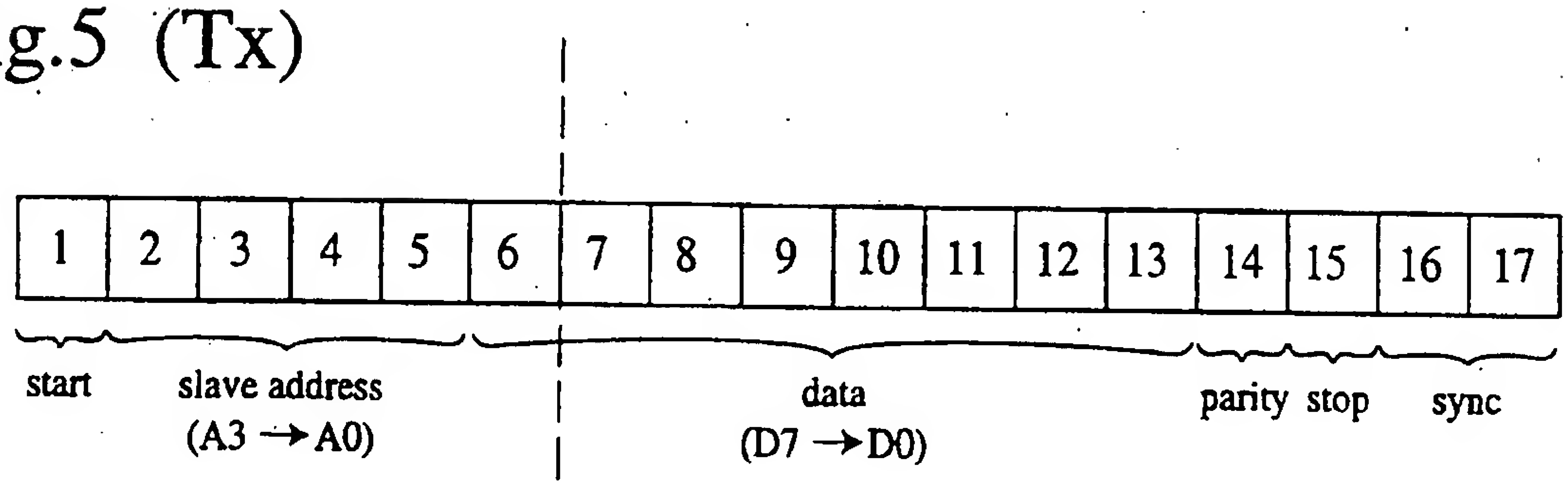
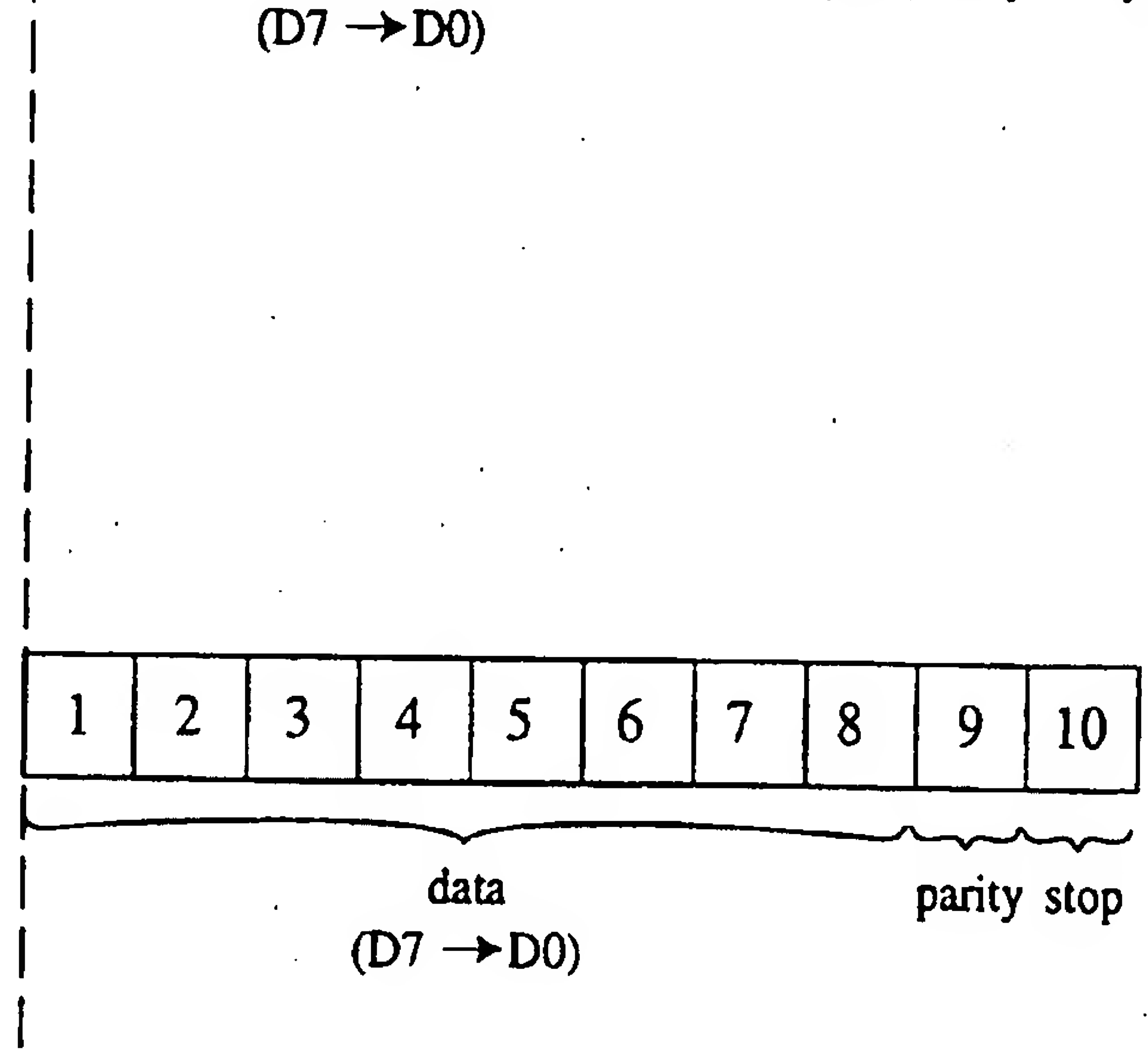


Fig.6 (Rx)



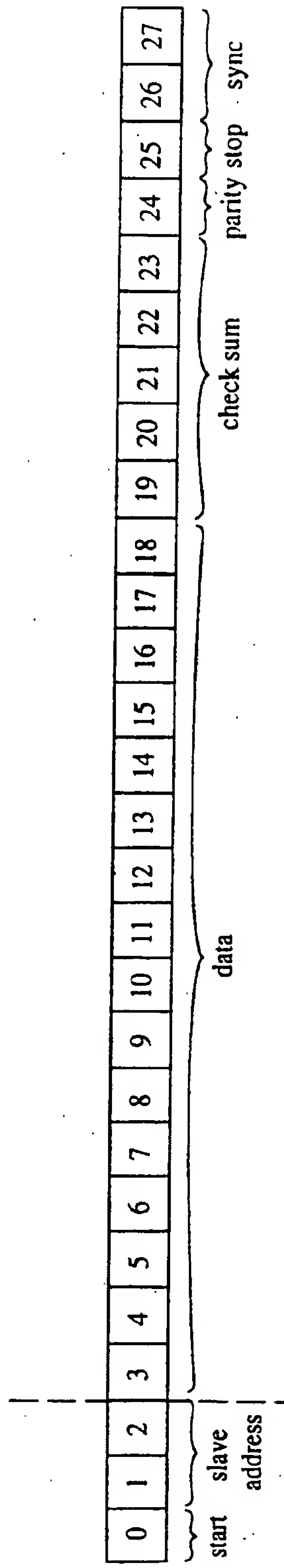


Fig.5a (Tx)

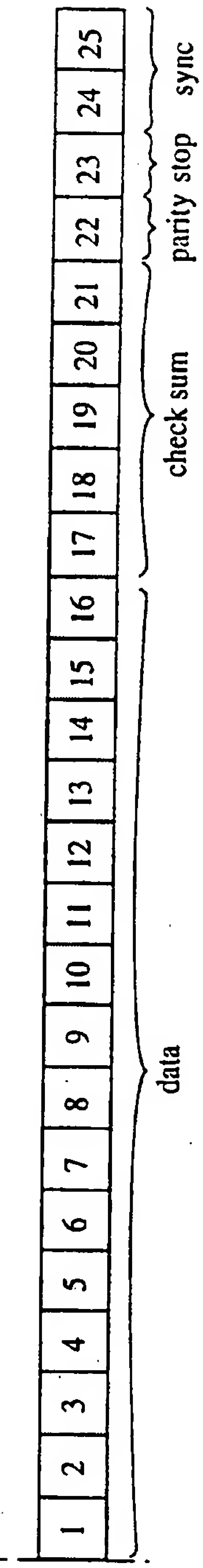


Fig.6a (Rx)

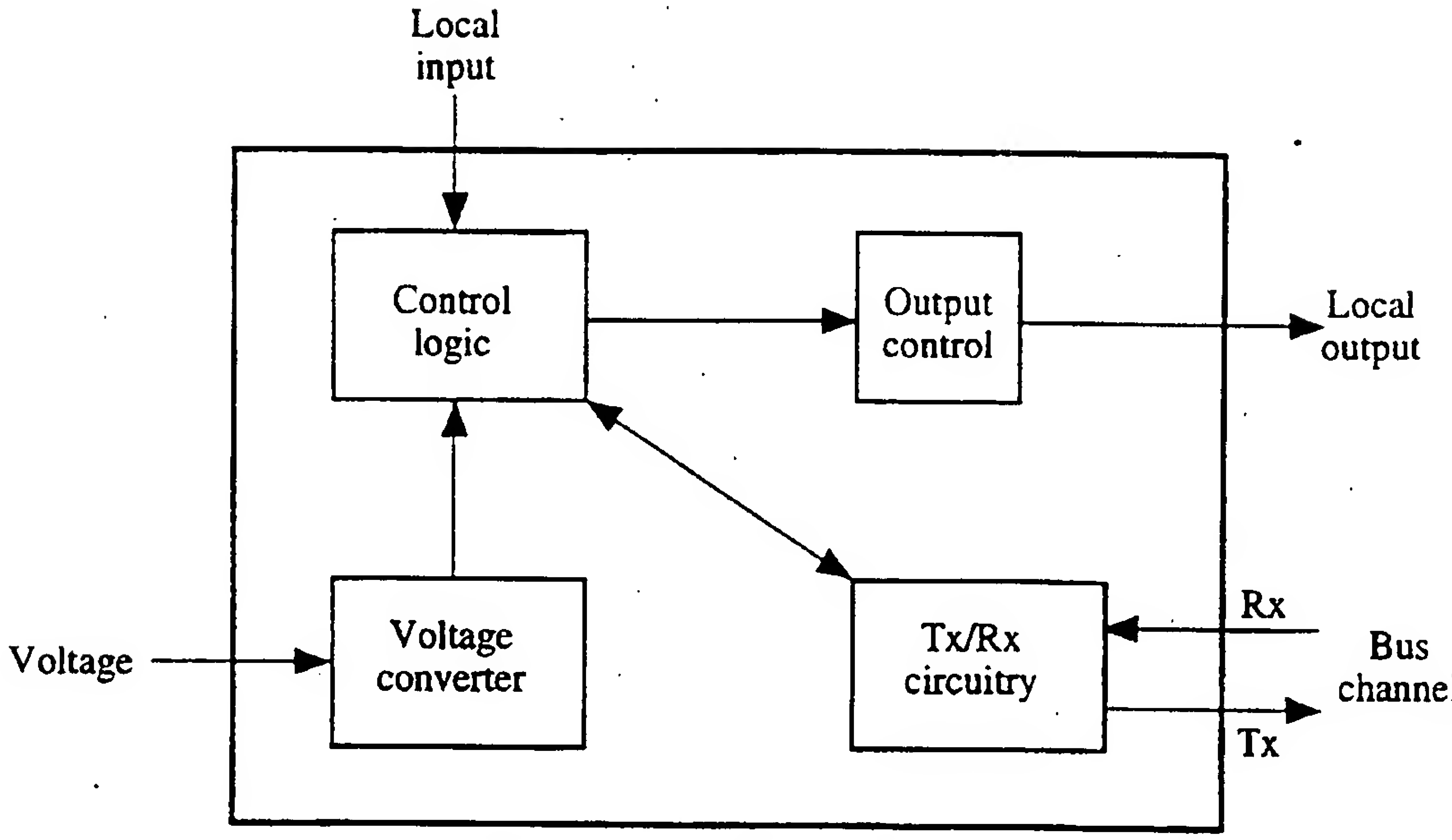

Local input
Control logic
Output control
Local output
Voltage
Voltage converter
Tx/Rx circuitry
Rx
Bus channel
Tx

Fig.7

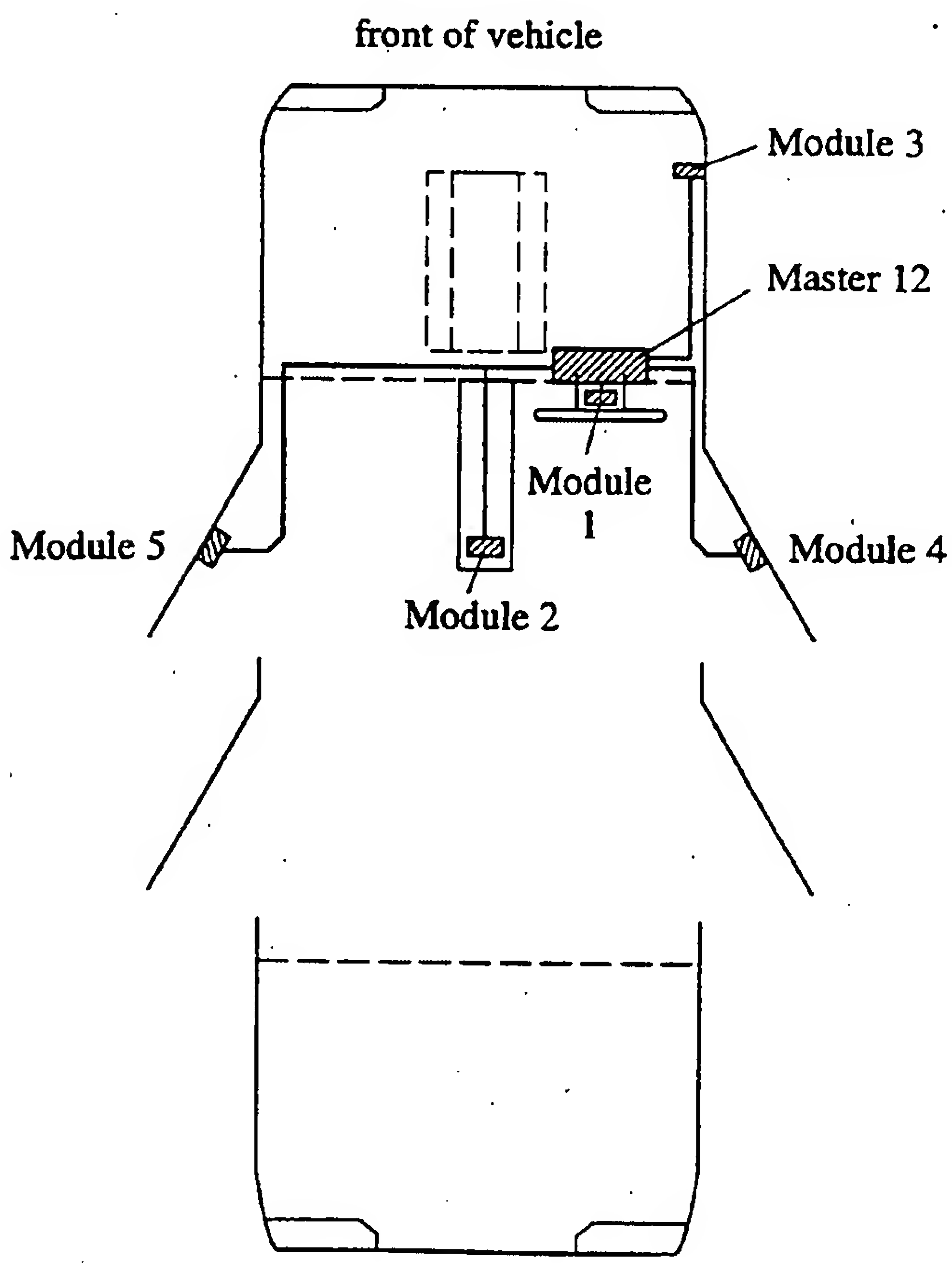
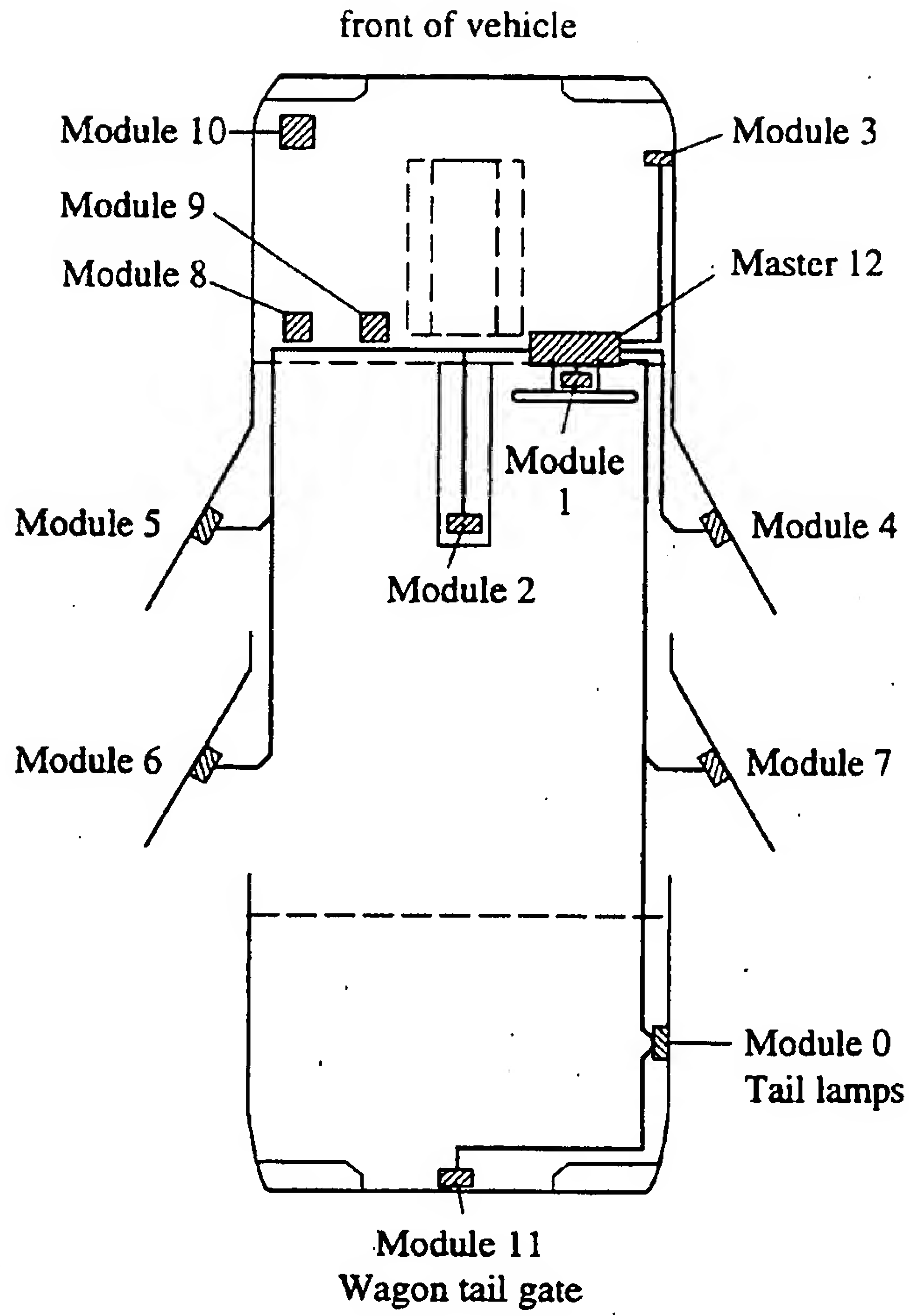

front of vehicle
Module 3
Master 12
Module 1
Module 5
Module 4
Module 2

Fig.8

Fig. 9


front of vehicle
Module 10
Module 3
Module 9
Master 12
Module 8
Module 1
Module 5
Module 4
Module 2
Module 6
Module 7
Module 0
Tail lamps
Module 11
Wagon tail gate

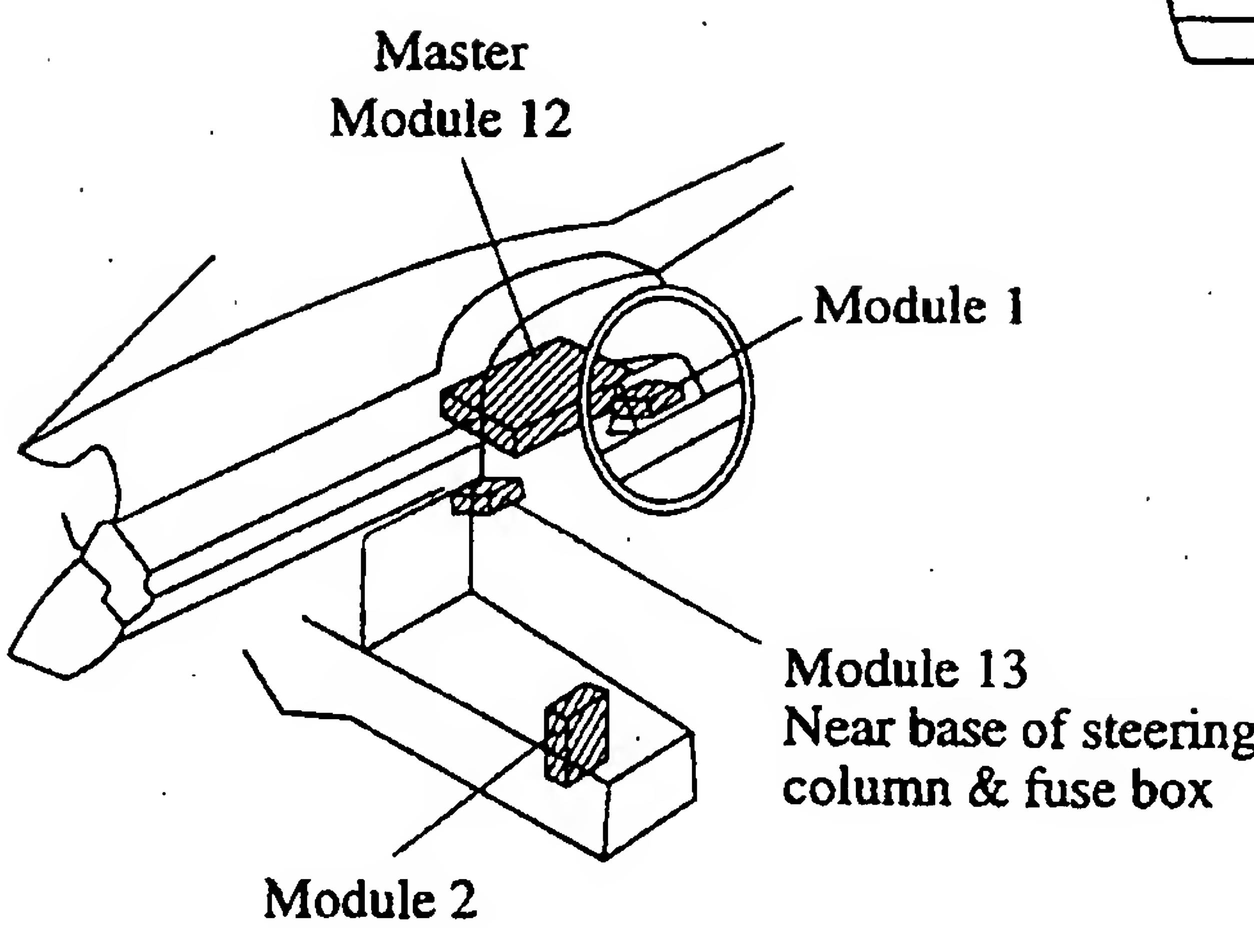

Master
Module 12
Module 1
Module 13
Near base of steering
column & fuse box
Module 2

Fig. 10

The Master to slave protocol		Slave to Master data transfer
Bit 1	Start bit logic high	
Bit 2	High address bit (A3)	
Bit 3	Address bit (A2)	
Bit 4	Address Bit (A1)	
Bit 5	Lowest address bit (A0)	
Bit 6	Highest data bit (D7)	Data Bit (D7)
Bit 7	Data Bit (D6)	Data Bit (D6)
Bit 8	Data Bit (D5)	Data Bit (D5)
Bit 9	Data Bit (D4)	Data Bit (D4)
Bit 10	Data Bit (D3)	Data Bit (D3)
Bit 11	Data Bit (D2)	Data Bit (D2)
Bit 12	Data Bit (D1)	Data Bit (D1)
Bit 13	Lowest data Bit (D0)	Data Bit (D0)
Bit 14	Parity Bit (even)	Parity bit (even)
Bit 15	Stop bit logic high	Stop bit logic high
Bit 16	Logic low	
Bit 17	Logic low	

Fig. 10a

	The Master to slave protocol	Slave to Master data transfer
Bit 0	Start bit logic high	
Bit 1	Highest address bit (A1)	
Bit 2	Lowest address bit (A0)	
Bit 3	Highest data bit (D15)	
Bit 4	Data Bit (D14)	
Bit 5	Data Bit (D13)	Data Bit (D15)
Bit 6	Data bit (D12)	Data Bit (D14)
Bit 7	Data Bit (D11)	Data Bit (D13)
Bit 8	Data Bit (D10)	Data Bit (D12)
Bit 9	Data Bit (D9)	Data Bit (D11)
Bit 10	Data Bit (D8)	Data Bit (D10)
Bit 11	Data Bit (D7)	Data Bit (D9)
Bit 12	Data Bit (D6)	Data Bit (D8)
Bit 13	Data Bit (D5)	Data Bit (D7)
Bit 14	Data Bit (D4)	Data Bit (D6)
Bit 15	Data Bit (D3)	Data Bit (D5)
Bit 16	Data Bit (D2)	Data Bit (D4)
Bit 17	Data Bit (D1)	Data Bit (D3)
Bit 18	Data Bit (D0) Lowest bit	Data Bit (D2)
Bit 19	Check sum highest bit (C4)	Data Bit (D1)
Bit 20	Check sum bit (C3)	Data Bit (D0)
Bit 21	Check sum bit (C2)	Check sum (C4)
Bit 22	Check sum bit (C1)	Check sum (C3)
Bit 23	Check sum lowest bit (C0)	Check sum (C2)
Bit 24	Parity Bit (even)	Check sum (C1)
Bit 25	Stop bit logic high	Check sum (C0)
Bit 26	Sync bit Logic low	Parity bit (even)
Bit 27	Sync Logic low	Stop bit Logic high

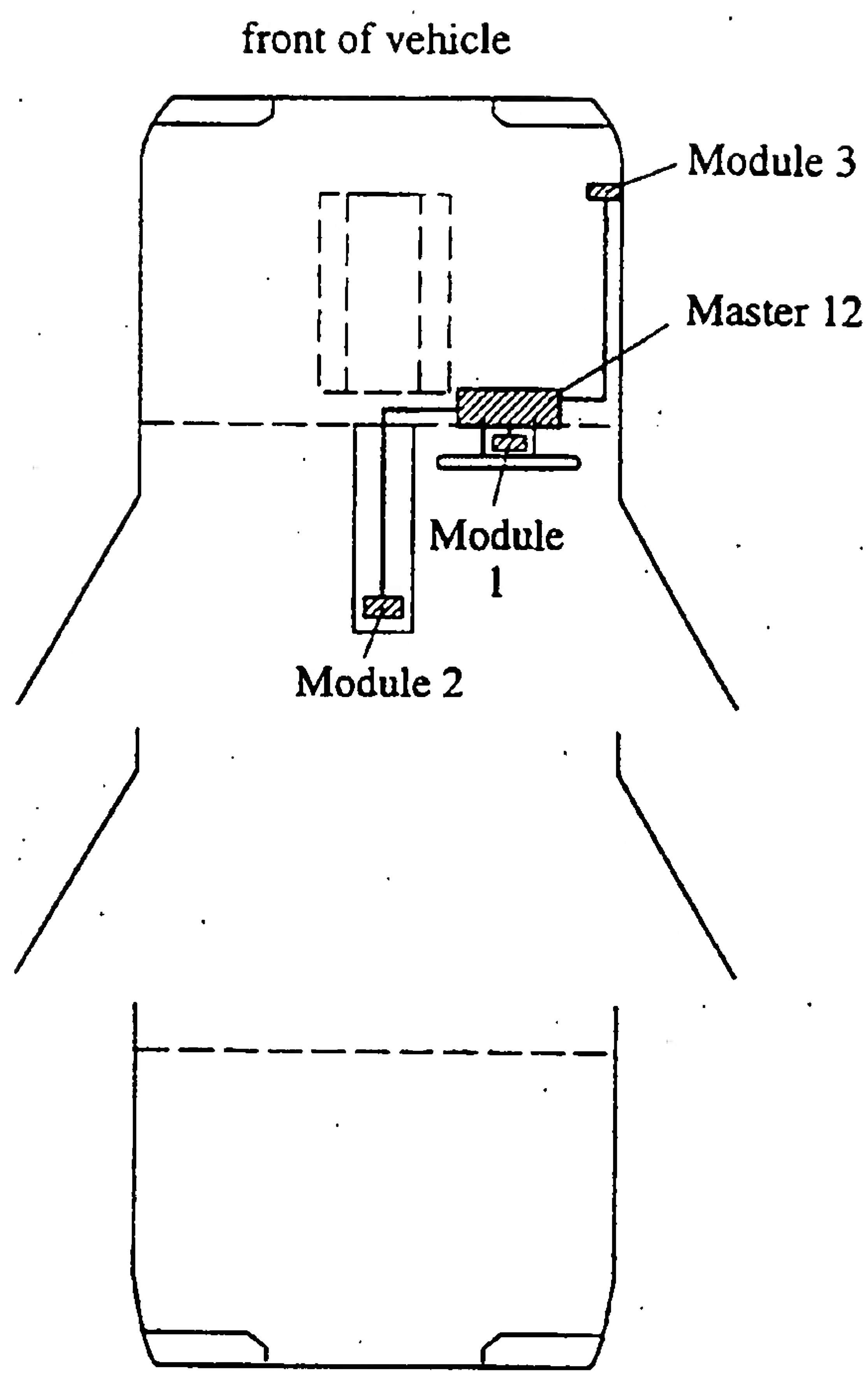


Fig. 11

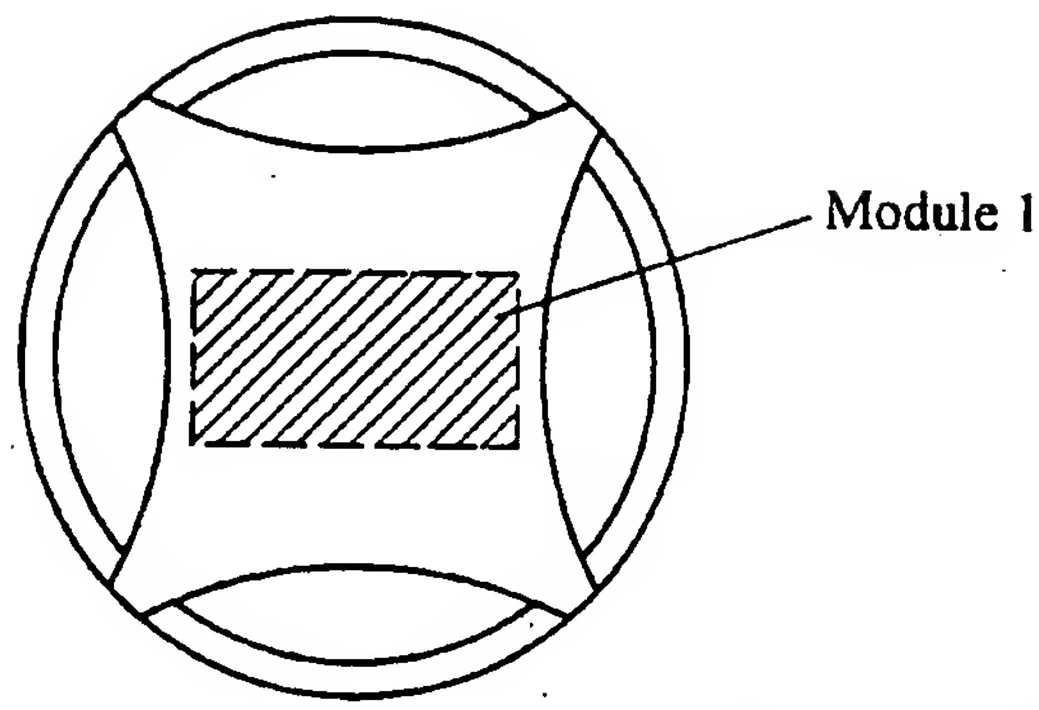


Fig. 12A

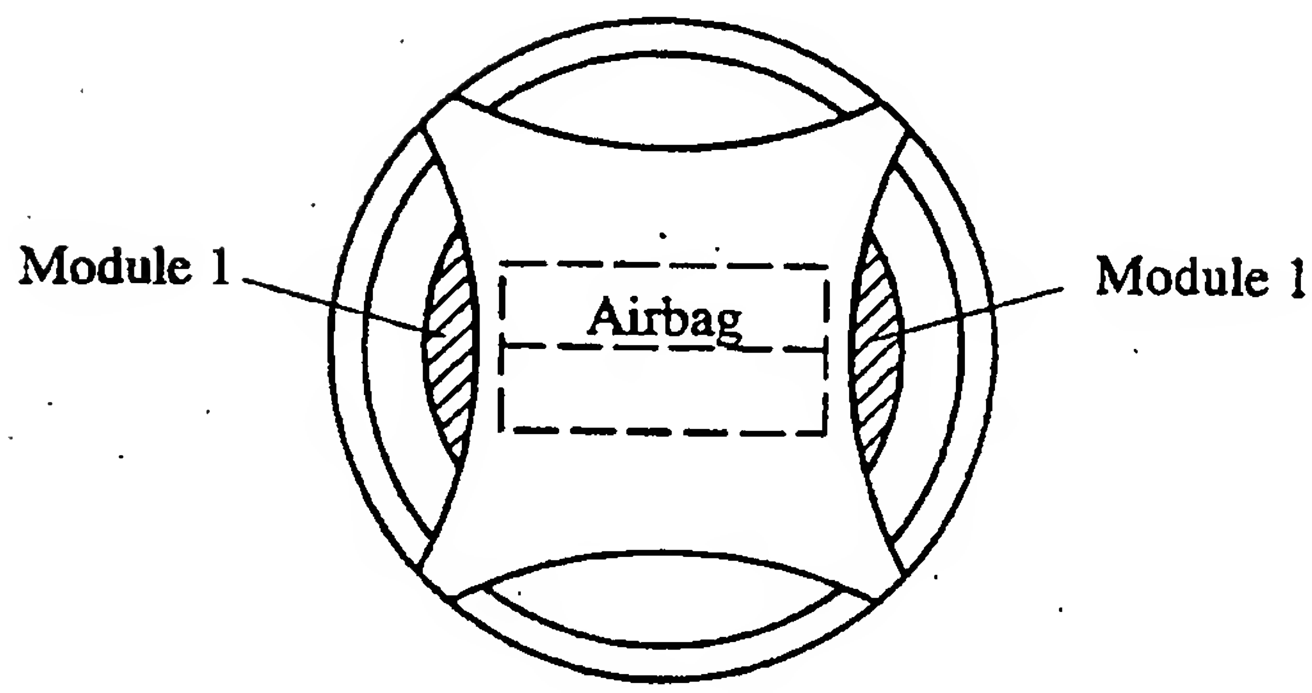


Fig. 12B

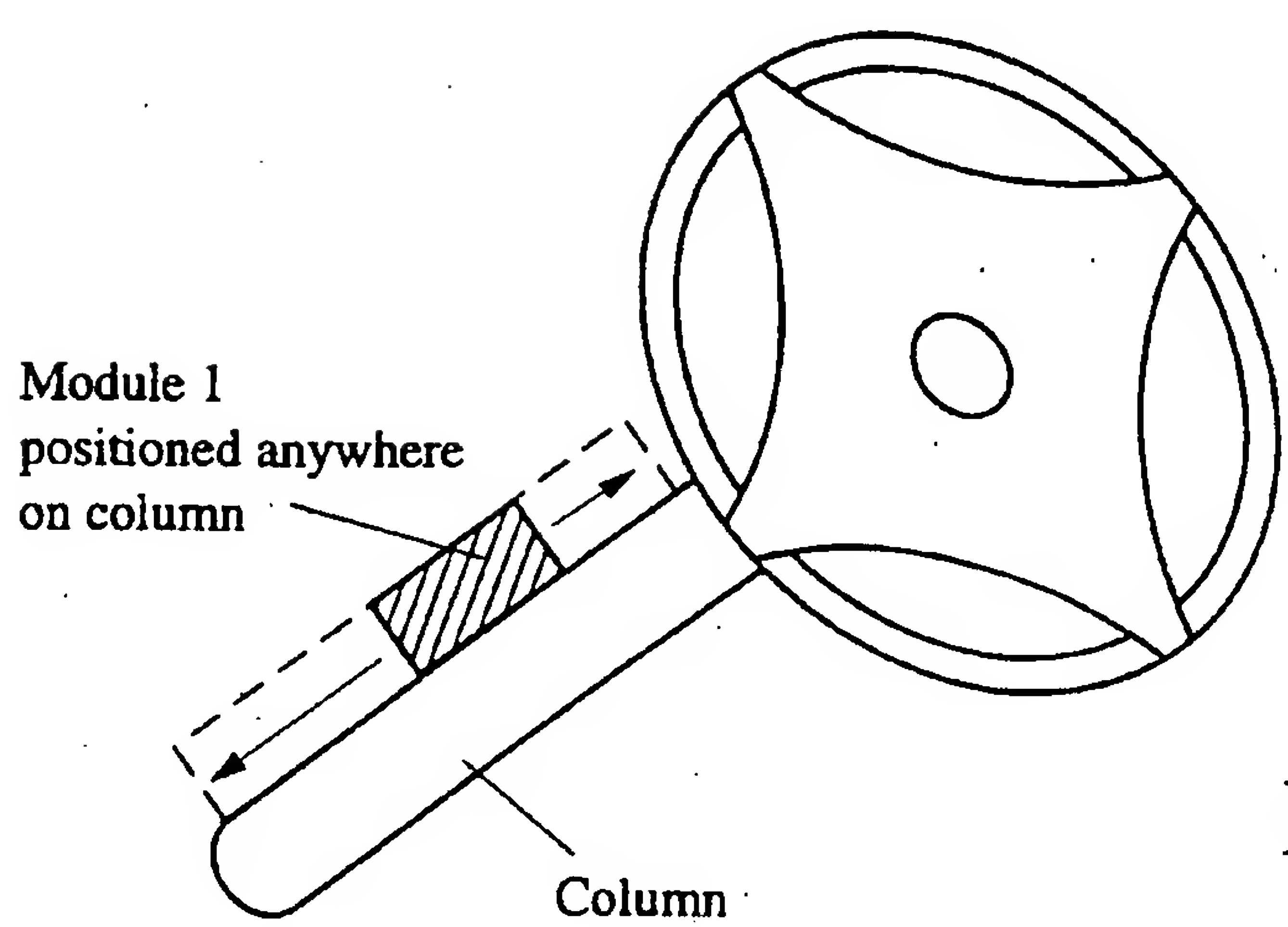


Fig. 12C

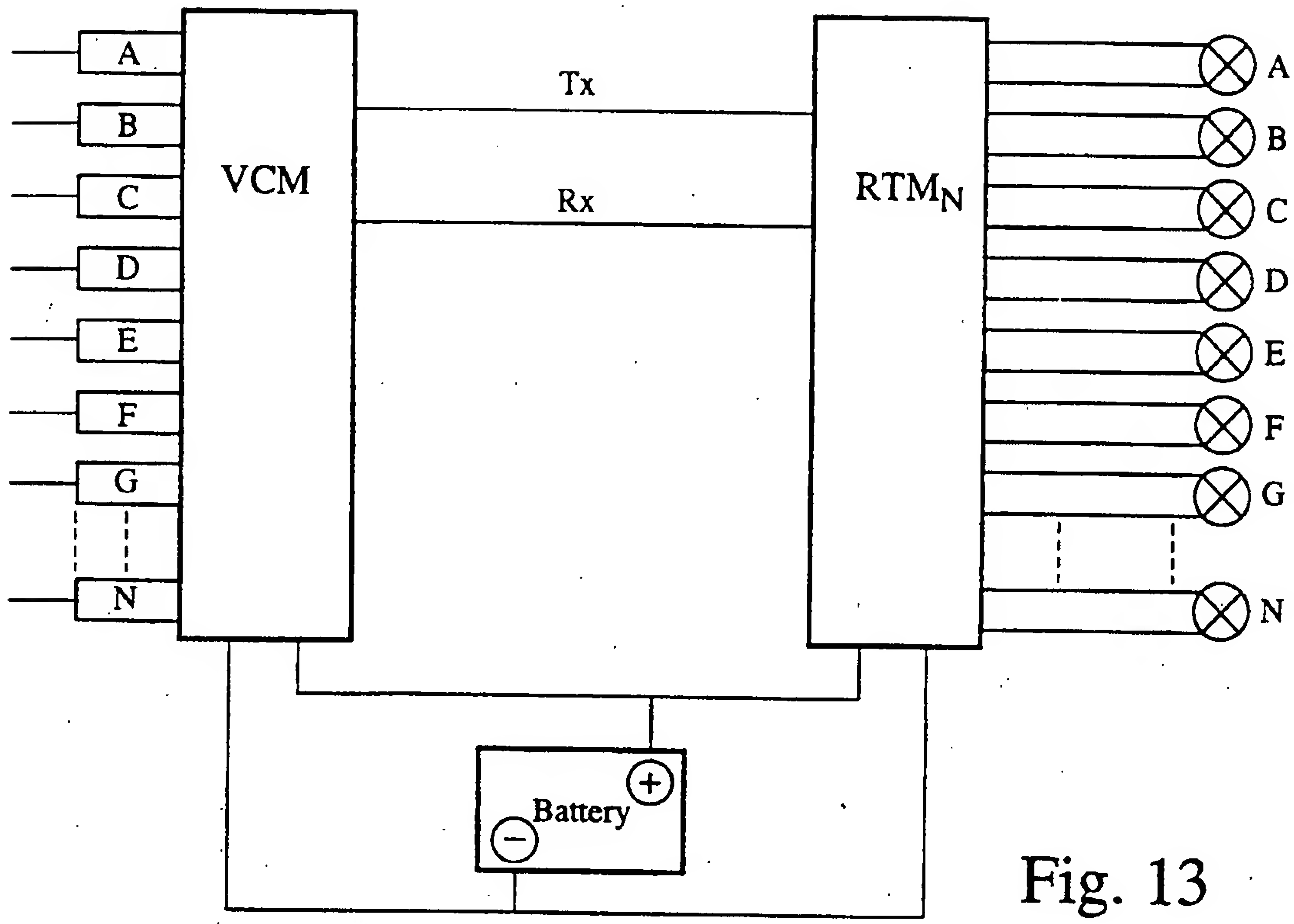


Fig. 13

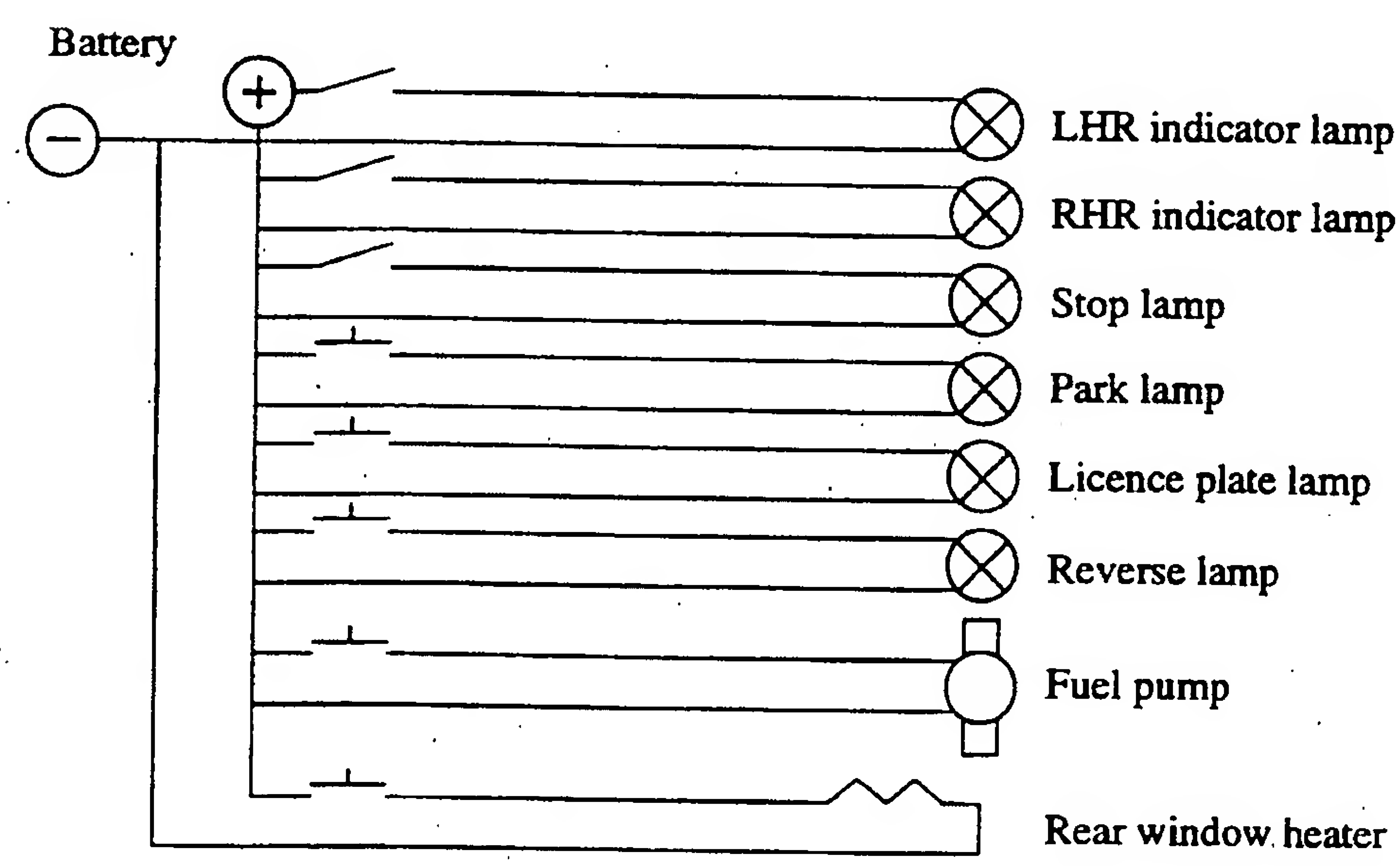


Fig. 14 prior art

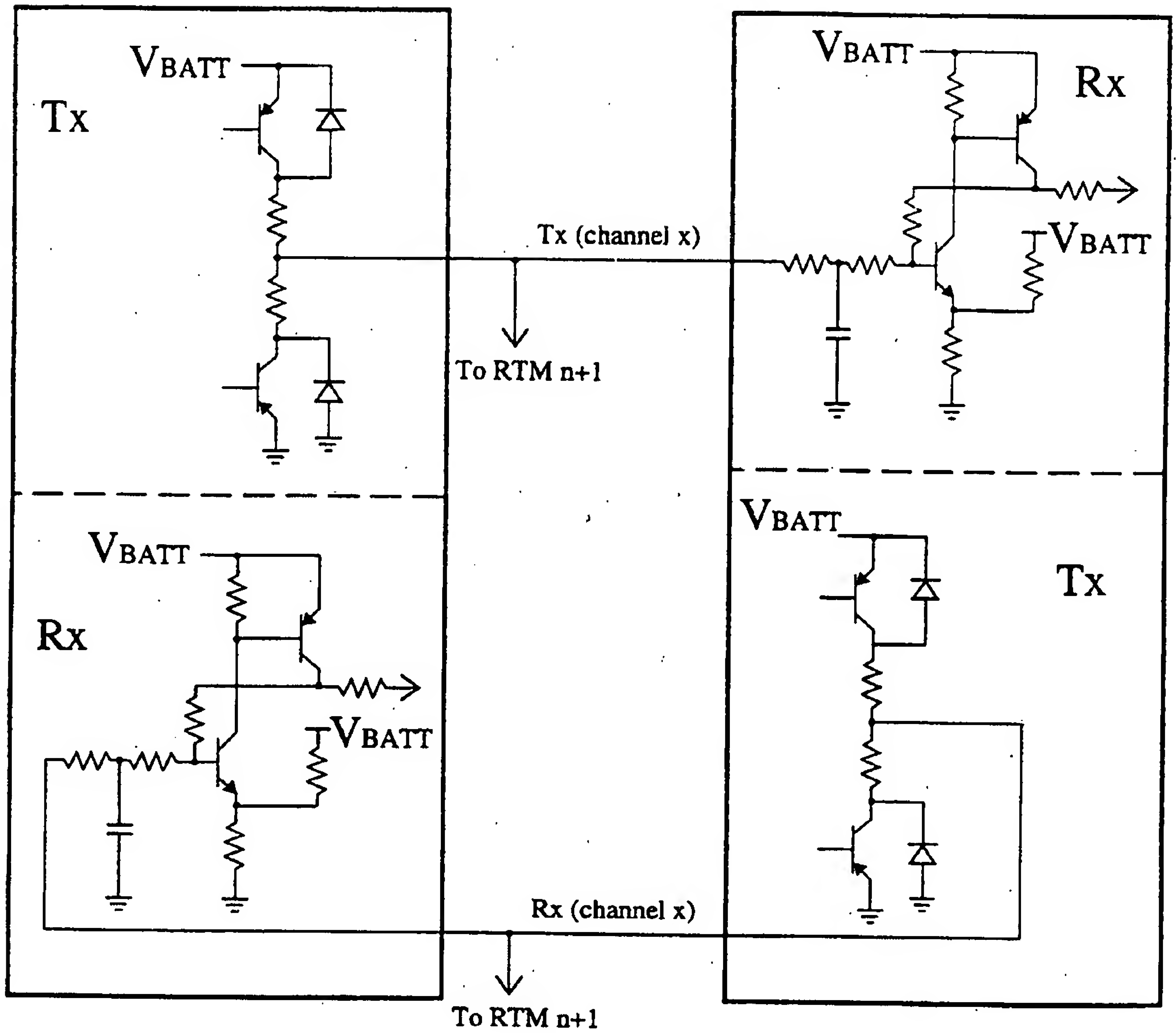

VBATT
Tx
Tx (channel x)
To RTM n+1
VBATT
Rx
VBATT
Rx
VBATT
VBATT
VBATT
Tx
Rx (channel x)
To RTM n+1

Fig. 15

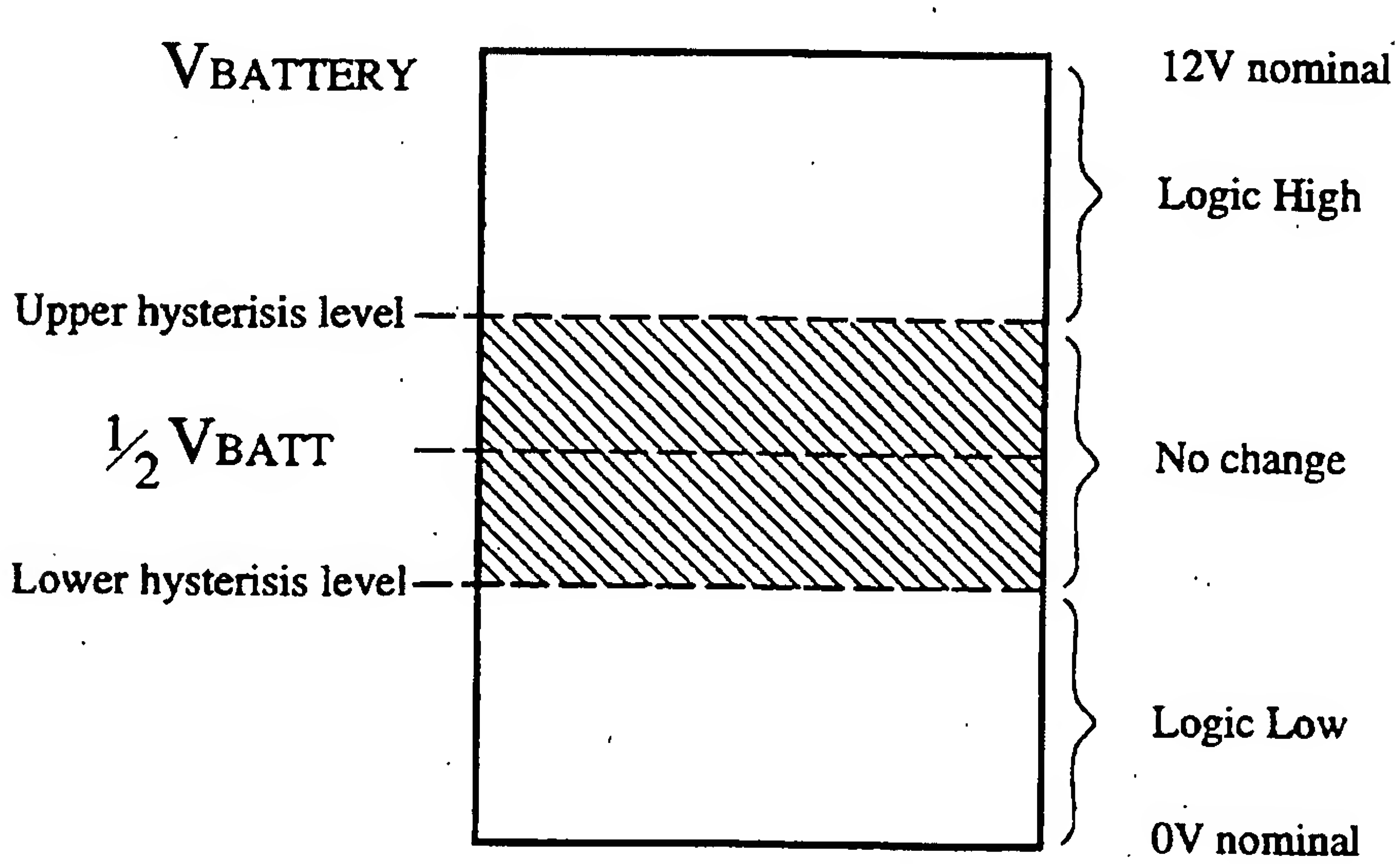

VBATTERY
12V nominal
Logic High
Upper hysterisis level
½ VBATT
No change
Lower hysterisis level
Logic Low
0V nominal

Fig. 16

A. CLASSIFICATION OF SUBJECT MATTER

Int. Cl.[5] B60R 16/02, H04L 5/00, 5/14, 29/02

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC : B60R 16/02, H04L 5/00, 5/14, 29/02

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
AU : IPC as above

Electronic data base consulted during the international search (name of data base, and where practicable, search terms used)
JOPAL

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to Claim No.
X	US,A, 5132680 (TEZUKA et al) 21 July 1992 (21.07.92) column 1 lines 7/11,20,24/30, column 3 lines 64/66, column 4 lines 25/32, claim 1, Figures 1 & 3	1,6,9-11,17-20
X	US,A, 5121386 (WOLFSGRUBEL et al) 9 June 1992 (09.06.92) Abstract, Figure 1, column 1 lines 54/56, column 2 lines 37/49, column 3 lines 20,25/32, column 6 lines 24/39,47/50	1-3,5,6,9-11,17-18
X	US,A, 5008877 (LEVINSON) 16 April 1991 (16.04.91) column 1 line 15, column 2 lines 21/32, column 4 lines 9/15, claims 1 & 5	9,10,12,16,18

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
26 August 1994 (26.08.94)	31 AUG 1994 (31.08.94)

Name and mailing address of the ISA/AU	Authorized officer
AUSTRALIAN INDUSTRIAL PROPERTY ORGANISATION PO BOX 200 WODEN ACT 2606 AUSTRALIA	R. FINZI
Facsimile No. 06 2853929	Telephone No. (06) 2832213

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate of the relevant passages	Relevant to Claim No.
X	US,A, 4969082 (OHO et al) 6 November 1990 (06.11.90) column 1 lines 40/65, column 5 lines 53/61, column 6 lines 14/22,33/46 Figures 1,2	1-7,9,11,17,18
X	US,A, 4937811 (HARRIS) 26 June 1990 (26.06.90) Figures 7 & 8, column 1 lines 5/10,62/66, column 2 lines 14/25, column 4 lines 6/11, column 5 lines 26/28, 65/68, column 7 lines 36/39,44/46,56/59, column 8 lines 19/21, Claim 14	1-3,5-7,9-11,17-20
A	US,A, 4894826 (AGGERS et al) 16 January 1990 (16.01.90) column 1 lines 52/54, column 2 lines 15/16, Abstract	14
X	GB,A, 2167885 (PRESSAC LIMITED (UNITED KINGDOM)) 4 June 1986 (04.06.86) Figures 1 & 2, page 1 lines 5/7,60/66,85/93, page 2 lines 6/22,64/67,72/83,102/105,120/124	1-6,9,11,19-23
X	EP,A1, 491095 (UNITED TECHNOLOGIES AUTOMOTIVE, INC) 24 June 1992 (24.06.92) column 1 lines 3/7, column 2 lines 44/57, column 3 lines 30/34, column 4 lines 6/9, column 5 lines 22/48, column 7 lines 22/24, column 8 lines 23/30	1-3,5-7,11,17,18
X	EP,A2, 470056 (MARELLI AUTRONICA SPA) 5 February 1992 (05.02.92) column 2 lines 16/23,44/48, column 3 lines 17/31	1-3,5,6,9-11,17,18

Box I **Observations where certain claims were found unsearchable (Continuation of Item 1 of first sheet)**

This international search report has not established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. [X] Claims Nos.: 8 & 11 when dependent upon claim 8
because they relate to subject matter not required to be searched by this Authority, namely:

Claims found unsearchable under Article 17.

Claim 8 is of indeterminate scope and has consequently been found to be unsearchable.

Claim 11 when dependent upon claim 8 is of indeterminate scope and has consequently been found to be unsearchable.

2. [ ] Claim Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. [ ] Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II **Observations where unity of invention is lacking (Continuation of item 2 of first sheet)**

This International Searching Authority found multiple inventions in this international application, as follows:

SEE ATTACHED

1. [ ] As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims

2. [ ] As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. [ ] As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. [ ] No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

[ ] The additional search fees were accompanied by the applicant's protest.

[X] No protest accompanied the payment of additional search fees.

(continuation)

Box II Observations where Unity of Invention is lacking

The International Application does not comply with the requirements of unity of invention because it does not relate to one invention or to a group of inventions so linked as to form a single general inventive concept. In coming to this conclusion the International Searching Authority has found that there are five inventions:

1. Claims 1-3 are directed to a control system for a vehicle which comprises a master module and three slave modules.

Claim 6 is directed to a vehicle control system which comprises a master module and at least one slave module.

Claims 9-10 are directed to a communication system having a master module with at least two buses with at least one slave module coupled.

Claim 17 is directed to a communication system having a master module and at least one slave module, where the master polls the slaves.

Claims 19-23 are directed to a coupling system that connects a master module to a plurality of spaced other modules, where there are at least two channels coupling the master module to the other modules.

Claim 11 when dependent upon claims 1-3,6,9-10 is directed to a vehicle including the system of the claim it is appended to.

Claim 18 when dependent upon claim 17 is directed to a vehicle including a communication system having a master module and at least one slave module, where the master polls the slaves.

It is considered that the provision of a master module and a slave module for a vehicle is the first special technical feature.

2. Claim 4 is directed to a vehicle control system having a module juxtaposed the steering wheel.

Claim 5 is directed to a vehicle control system having a module juxtaposed the vehicle centre.

Claim 11 when dependent upon claims 4,5 is directed to a vehicle including the system of the claim it is appended to.

It is considered that the positioning of the module in the vehicle is the second special technical feature.

3. Claim 7 is directed top a control system in which there is provided a master module coupled directly to an instrument cluster.

Claim 11 when dependent upon claim 7 is directed to a vehicle including the system of the claim it is appended to.

It is considered that the coupling of the module directly to an instrument cluster is the third special technical feature.

4. Claims 12-13 are directed to a method of communication in which data is transmitted asynchronously one way and synchronously the other way.

Claim 15 when dependent upon claims 12-13 is directed to a method of communication in which data is transmitted asynchronously one way, synchronously the other way and the reply transmission overlaps the received transmission in time.

Claim 16 when dependent upon claims 12-13 or when dependent upon claim 15 when dependent upon claims 12-13 is directed to a communication system which uses the method of communication of claims 12-13 in which data is transmitted asynchronously one way and synchronously the other way.

Claim 18 when dependent upon claim 16 when dependent upon claims 12-13 or when dependent upon claim 16 when dependent upon claim 15 when dependent upon claims 12-13 is directed to a vehicle including a communication system which uses the method of communication of claims 12-13 in which data is transmitted asynchronously one way and synchrononsly the other way.

It is considered that the transmitting data one way asynchronously and the other way synchronously is the fourth special technical feature.

5. Claim 14 is directed to a method of communication in which a reply transmission is initiated before the completion of the re ceived transmission.

Claim 15 when dependent upon claim 14 is directed to a method of communication in which a reply transmission is initiated before the completion of the received transmission such that the reply transmission overlaps the received transmission in time.

Claim 16 when dependent upon claim 14 or when dependent upon claim 15 when dependent upon claim 14 is directed to a communication system which uses the method of communication of claim 14 in which a reply transmission is initiated before the completion of the received transmission.

Box II (continued)

Claim 18 when dependent upon claim 16 when dependent upon claim 14 or when dependent upon claim 16 when dependent upon claim 15 when dependent upon claim 14 is directed to a vehicle including a communication system which uses the method of communication of claim 14 in which a reply transmission is initiated before the completion of the received transmission.

It is considered that transmitting a reply before the whole message has been received is the fifth special technical feature.

Since the above mentioned groups of claims do not share anay of the technical features identified, a "technical relationship" between the inventions, as defined in PCT rule 13.2 does not exist. Accordingly the international application does not relate to one invention or to a single inventive concept.

The International Searching Authority considers that inventive concept (3) in regard to claim 7 and claim 11 when dependent upon claim 7 can be searched without effort justifying an additional fee.

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report		Patent Family Member					
US	4969082	CN	85107028	EP	192819	EP	487503
		JP	61194942	US	4855896		
US	4937811	CA	2002782	EP	384259	JP	2266628
US	4894826	CA	2005898	EP	381387	JP	2238745
GB	2167885			NONE			
EP	491095			NONE			
EP	470056	IT	1240519				
US	5132680	AU	46016/89	CA	2004934	EP	372567
		JP	2156750				
US	5121386	EP	396090	IT	1232089	JP	3128543
US	5008877	CA	1323407	EP	269418	JP	63141422
							END OF ANNEX